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PINON AND JUNIPER
PRELIMINARY STUDY OF VOLUME,
GROWTH AND YIELD

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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Region 8
Albuquerque, New Mexico

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PINON AND JUNIPER

A

PRELIMINARY STUDY OF VOLUME, GROWTH AND YIELD

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PINON AND JUNIPER

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PRELIMINARY STUDY OF VOLUME, GROWTH AND YIELD

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A PRELIMINARY STUDY OF VOLUME, GROWTH AND YIELD

A. - FOREWORD

No previous detailed studies have been made to show how volume, growth and yield tables should be prepared for species represented in the coniferous woodland (pinon-juniper) stands of northern New Mexico and Arizona. Extreme variations in habit of growth make the problem a complicated one.

This study is based upon many individual trees occurring over a wide range of sites in various localities. While data were secured on a limited number of plots, which could not be expected to provide conclusive findings, nevertheless enough plots were taken to give a good indication of the range of conditions normally found.

Due to limited time, methods of statistical analysis were not used in all determinations. Statistical analysis was used occasionally to provide checks but these checks are not included in this bulletin.

Discrepancies will be found. Some are due to methods of handling data, while others resulted from wide variations encountered throughout the coniferous woodland stands. The all-aged character of woodland stands, as well as the varying species found thereon, prevents the use of conventional and standard methods of preparing yield tables.

Additional plots are needed in each of the woodland types before sufficient data are available to prepare satisfactory yield tables.

B. - INTRODUCTION

Pinon* (*Pinus edulis*, Engelmann) and one-seed juniper* (*Juniperus monosperma*, (Engelmann) Sargent) with a scattering of Rocky Mountain red cedar* (*Juniperus scopulorum*, Sargent) cover extensive areas in Colorado, Utah, New Mexico, and Arizona. Throughout their range, these species occupy more land area than the sawtimber forest types. Due to its occurrence near locations of settlement, the pinon and juniper type has been used in varying degrees of intensity to provide products for human use. The major products produced by this type are fuel, posts and pinon nuts. Under given market conditions, pinon is used for mine props and for narrow gauge railroad ties. When large enough, Rocky Mountain red cedar may be sawed into boards which are used for various special purposes.

Throughout the Southwest, products from the pinon-juniper type provide in varying degree a cash return to subsistence populations through the sale of posts, fuelwood and pinon nuts. For home consumption and for sale, the value of woodland products in the aggregate amounts annually to a considerable sum.

In some localities the past continuous drain has resulted in marked depletion. This depletion may be expressed in terms of dry or green fuelwood material with depletion of dry fuelwood most noticeable. Depletion of fence post material is more in evidence and covers extensive areas of the coniferous woodland type.

* The three species included in this study. There are several other species in the coniferous woodland type on which no data were gathered.

Cutting practices employed in removal of fence posts are far from conservative and from observations made it appears that indiscriminate cutting of smaller stems to reach material of post size has resulted in the loss of quantities of future fence post material which has taken a long time to produce. Also, the cutting of stems for fuel which, if left, would eventually make posts, has also contributed to depletion of post resources.

Beside the tangible values of wood products and pinon nuts may be noted the watershed protective values of this type, which is extremely important at higher elevations where the type approximates closed stand conditions.

Presumably the relative abundance of the woodland area, its use for range livestock - considered by many to be its most important value - and general lack of public and individual appreciation of the values of watershed protection, wood products and pinon nuts, has resulted in a general lack of appreciation of the true value of this type which has too often been expressed in terms of misuse.

This feeling that the coniferous woodland type is of minor importance is also reflected in the scarcity of literature regarding the species forming the type and absence of published material pertaining to volume, growth, and yield.

The pinon juniper stands lie between the sawtimber forests and the semi-desert grass lands either as a fringe or as isolated patches. In this study only that portion of the area covered by this coniferous woodland was examined which is located in Northwestern New Mexico and Northeastern Arizona. (See Figure 1.)

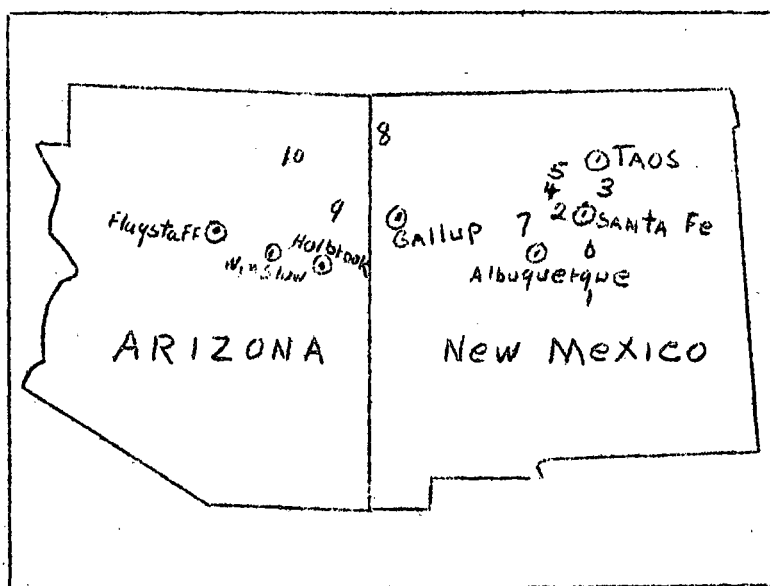


Figure 1. Distribution of Sample Plots.

1. Mountainair, New Mexico
2. Caja del Rio Grant, New Mexico
3. Sebastian Martin Grant, New Mexico
4. Ramon Vigil Grant, New Mexico
5. South Lobato Grant, New Mexico
6. San Pedro Grant, New Mexico
7. Espiritu Santo Grant, New Mexico
8. Cove, New Mexico
9. Pine Springs, Arizona
10. Forest Lake, Arizona

Woodland stands vary in form from scattered individuals or clumps of trees to dense stands. Variation in site condition is generally greater than in sawtimber stands. Seldom, if ever, are pure stands found covering large areas. This type is normally all-aged but occasionally exceptions occur as the relatively pure and even aged pinon stands that come in on favorable sites after clear cutting.

One-seed juniper stands are characterized by wide spaced many-stemmed trees, bushy crowns, low stature except on the better sites and many grassy openings. As one travels to higher elevations, more and more pinon occurs as a component of the stand with a corresponding decrease in the quantity of one-seed juniper. The pinon type is often composed of close set trees of narrow crowns and exhibits forest conditions with a closed crown canopy and litter and humus on the forest floor. With increase in elevation and a corresponding increase in moisture the grassy openings become fewer in number until they are largely relegated to the deeper soils as a fringe along the drainages.

Pure or relatively pure stands of Rocky Mountain red cedar are seldom found. This species usually occurs as isolated trees or as groups of trees in mixture with one-seed juniper, pinon, oaks and ponderosa pine at higher elevations in the pinon-juniper type. Relatively pure stands may appear on deeper soils as a narrow fringe along drainage-ways with trees of all ages present.

C. - DEFINITIONS

1. Acre. 43,560 square feet measure on a horizontal projection of the ground surface.

2. Age. Total age of the tree based upon a stump count and corrected for years to reach a height of one foot. Average age to one foot.

Pinon, 9 years

One-seed juniper, 13 years

Rocky Mountain red cedar, 8 years

3. Average diameter. Average diameter at breast height or at one foot of an entire stand or part of a stand computed by dividing the total basal area of the trees by their number and converting the quotient to diameter either inside or outside the bark.
4. Basal area. The cross sectional area in square feet at one foot or at breast height where B.H. measurements are used, outside or inside bark.
5. Breast height. A point of measurement on the main stem located 4.5 feet above the average ground level.
6. Branches. Those stems originating above or below stump height which form separate units.
7. Brush volume. All the green and dry brush (branches) suitable for use in soil and moisture conservation operations, i.e., all limb material not included in cubic volume.
8. Crown density. The amount of space occupied by the crowns as expressed in per cent. Determined by summing up all crown spread in square feet on a unit area and then dividing by the number of square feet in the unit area.
9. Crown length. The distance in feet from the tip of the tree to the lowest green branch.

10. Crown spread. The average width of a tree crown as determined from two diametrically opposite measurements from one extreme branch tip to the other. Sometimes referred to as crown width. It may also mean the area in square feet as determined from average crown width which may be used to determine crown density.
11. Cord. The standard cord of 4x4x8 feet.
12. Cut trees. Trees that have been cut but originally formed a part of the stand.
13. Dominant classes. The Swedish System was used in this study. The fourteen classes used in field measurements (See Appendix) were reduced to six, as follows:
 - a. Dominant. The largest, tallest and most vigorous trees in the stand. In some stands the dominant trees may be decadent due to age.
 - b. Co-dominant. Usually well developed trees reaching into the main canopy. If not widely spaced, there is some pressure on the sides of the crowns. Some of these may later become dominant.
 - c. Intermediate. Trees of inferior development. Considerable side pressure if in closed or partially closed stands. Some may, through release, develop into co-dominants or dominants.
 - d. Suppressed. Trees that are distinctly inferior. These may, through release, develop into one of the three classes noted above.
 - e. Dead. Dead standing trees.
 - f. Reproduction. All trees less than 4.5 feet tall.

14. Fence posts. For the junipers only. Standard line posts 7 feet long and 5 inches top diameter outside bark, or the equivalent of 20 square inches for split posts. While this will give the maximum yield of standard line posts, actual yield will be somewhat lower due to hidden defect and difficulties of splitting.
15. Height. The total height of the tallest stem from the average ground level to the tip of this stem.
16. Mean annual increment. The average annual volume growth of the tree from the year of origin to the age under consideration.
17. Main stem. The tallest stem or branch of the tree or clump.
18. Normal or fully stocked stand. A stand that utilizes its site to the fullest extent allowed by soil and moisture conditions. Density will, therefore, vary widely. The crown canopy need not be closed or complete. Maximum stocking is not implied although it may occur in some localities.
19. Number of trees per acre.
 - a. Total. All trees on an acre regardless of size.
 - b. Partial. All trees above four and one-half feet in height.
 - c. Reproduction. All trees less than four and one-half feet in height. These were recorded by height classes.
20. Partially cut trees. Trees from which green or dry branches or stems have been harvested for fuel or fence posts.
21. Partial stand. Those trees above 4.5 feet in height or trees sufficiently large to produce wood products as fuel, posts, etc.
22. Pieces. Sticks four feet long and two inches or more in diameter at the middle, outside bark.

23. Polos. Straight stems at least eight feet long having specified minimum top diameters. Suitable for mine props, ties, corral poles, etc.
24. Periodic annual increment. Average annual volume growth within a given age interval; in this study 10 years.
25. Site index. Basal area in square feet of all trees over 4.5 feet in height, in terms of an average diameter outside bark for the partial stand of five inches at one foot above the average ground level. Example: When the "site index" is "50", it means that when the average diameter of the partial stand is five inches, the stand will have a basal area of 50 square feet.
26. Site quality. The site quality of a woodland area is its relative productive capacity as determined by climate, soil and other factors. Only three site classes are suggested at this time.
27. Stocking. The degree to which the productivity of an area is utilized by the existing forest stand.
28. Stump height. All trees in this study were cut and measured at a point one foot above the average ground level.
29. Tree. Single or multiple stemmed. Example: In one-seed juniper many stems start at below or above the ground surface or from a short primary bole. The entire clump is considered to be one tree.
30. Volume table. Tables showing the estimated volumes of trees of various sizes, expressed in cubic feet or other standards of measurement.

31. Woodland. Woodland as used in this report refers to pinon-juniper stands. Only 3 species (*J. monosperma*, *J. scopulorum* and *P. edulis*) were included in this study.

D. - BASIC DATA

Standards of measurement and forms on which data were recorded are noted in the appendix.

1. Plots. The data used in the preparation of volume tables and other findings noted in this report were secured by five investigators working in localities in Arizona and New Mexico noted in Figure 1.

Trees in the plots established were selected to represent the range of diameters, heights and form most typical of the woodland stands encountered. Thirty-nine plots were taken. Each plot was so located as to contain about 200 trees over 4.5 feet in height. Data and the manner in which it was to be procured were based upon a working plan. The distribution of the thirty-nine plots by area and by types follows:

Table 1. Size of Study Plots by Types*

Area of Plots Acre	Number of Plots by Type			
	All Plots	Juniper Type	Pinon Type	Pinon-Juniper Type
Less than 0.5	13	3	4	7
0.5 to 0.99	14	5	5	3
1.0 to 1.49	9	4	4	1
1.5 to 1.99	2	2	0	0
Over 2.0	1	1	0	0
Total	39	15	13	11
Average Size Acres	0.800	1.061	0.688	0.509

* See Section G - "Composition of Woodland Stands" for basis of type determinations.

The total area covered by plots was 30.609 acres. The smallest plot was 0.20 acre and the largest 3.705 acres.

None of the plots were rejected for abnormality since not enough plots were taken on which to base definite conclusions in this respect. Limited funds, together with the time necessary to gather data on each plot, limited the scope of the study in terms of the number of plots that could be taken.

2. Field Measurements and Forms. Study plots were laid out with a Forest Service compass and steel tape. Individual tree measurements were recorded on Form PSP1 for each tree over 4.5 feet in height. All measurements were made with a steel tape or graduated rod. Reproduction was recorded by species in terms of three height classes. On the reverse side of the form, general information concerning the plot was entered.

Twenty-five trees were selected at random for cutting on each plot. These were distributed among the three species and by diameter at one foot and height classes. Additional trees of exceptional size were taken where time permitted. Form VS 1-38 was filled in for each tree in accordance with the definitions of terms under standards of field measurement as noted in the appendix.

3. Office Computations. Wherever possible, statistical methods of analysis were used. Due, however, to extreme range in variation, as well as lack of time to fully analyze data by this means, it was often necessary to resort to graphic methods.

E. - VOLUME TABLES

Volume tables in terms of cubic volume were prepared using different groups of measurements to determine those most suitable and reliable for use in predicting volume. Converting factors for cord volume were also ascertained. For pinon, diameter at breast height and number of four-foot pieces were found to give the best results; for one-seed juniper and Rocky Mountain red cedar, diameter of the tallest stem at one foot and crown diameter. These volume tables have already been issued and will be found in Regional Bulletin No. 59, Woodland Series No. 8 including Supplement No. I. For these volume tables the aggregate deviations were readily reduced to less than two per cent; however, it would be difficult to reduce the average percentage deviations below 50 per cent for the junipers noted or 25 per cent for pinon without undue manipulation and adjustment.

The cubic volume in the tables includes that contained in sticks four feet long and two inches or more in diameter, outside bark, at the center. The volume of each stick was computed by Huber's formula. Bark is included but the stump excluded from these volumes. The preliminary alignment chart was constructed after the methods of Bruce and Reinecke; however, subsequent adjustments were made by graphic methods.

These tables are regional tables. They should be corrected for local use by standard methods. Actual measured volume should be obtained for at least 100 trees due to the wide variation in volume found. Comparison of a local and the regional curve is noted in Figure 2.

Other volume tables are included (Figures 3, 4 and 5). These present cubic and brush volumes for the three species. Figuring a certain percentage of the brush to be removed for use in erosion control operations, one could decide to remove, for example, one-tenth of the brush volume and construct a curve covering this amount applying from an extensive cruise the diameter classes tallied to determine the quantity of brush available.

Tables 2, 3 and 4 are self-explanatory and present some interesting averages as well as other useful data.

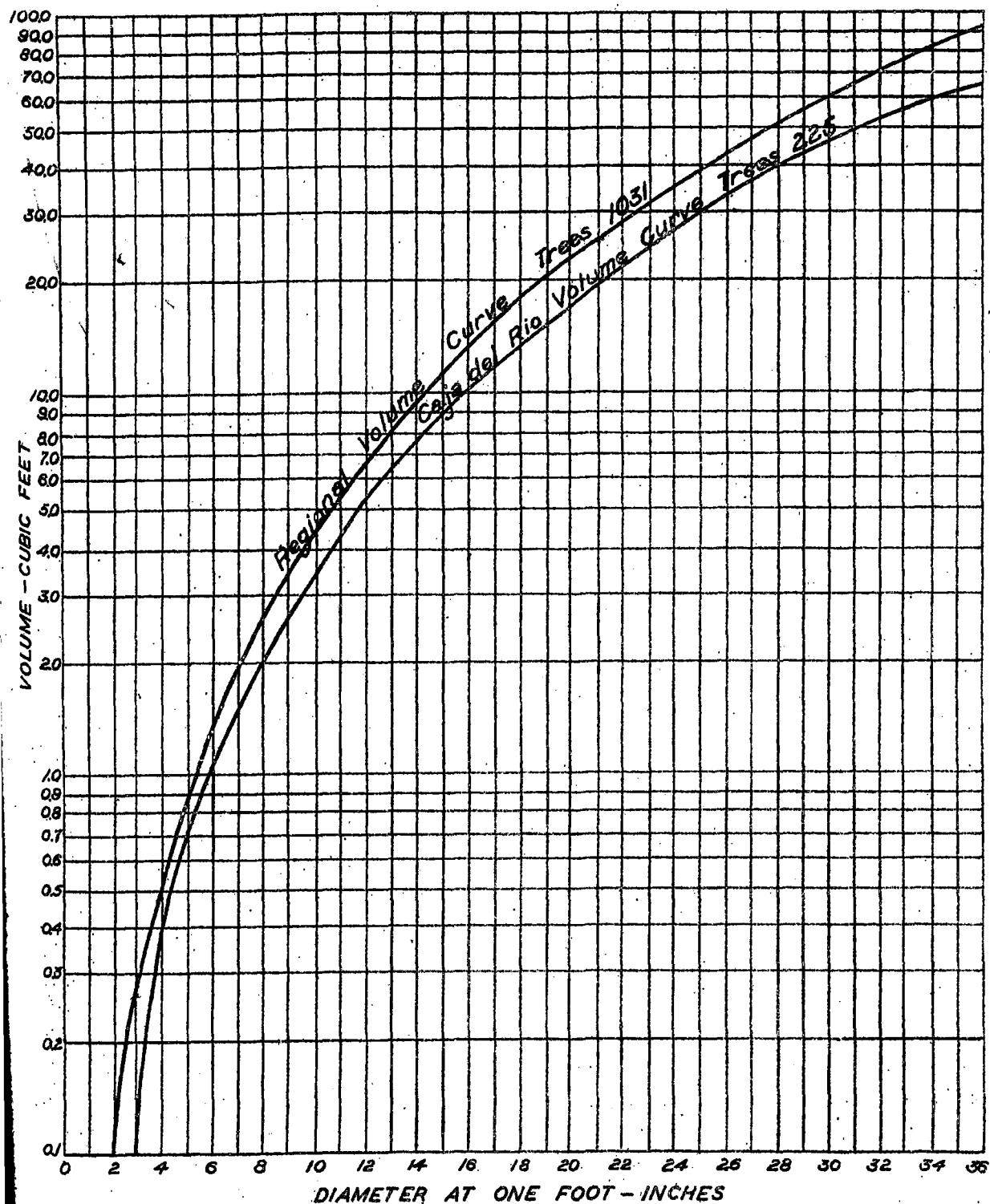


Figure 2. Comparison of Regional Volume Curve with that for trees of one-seed juniper from the Caja del Rio Grant, New Mexico.

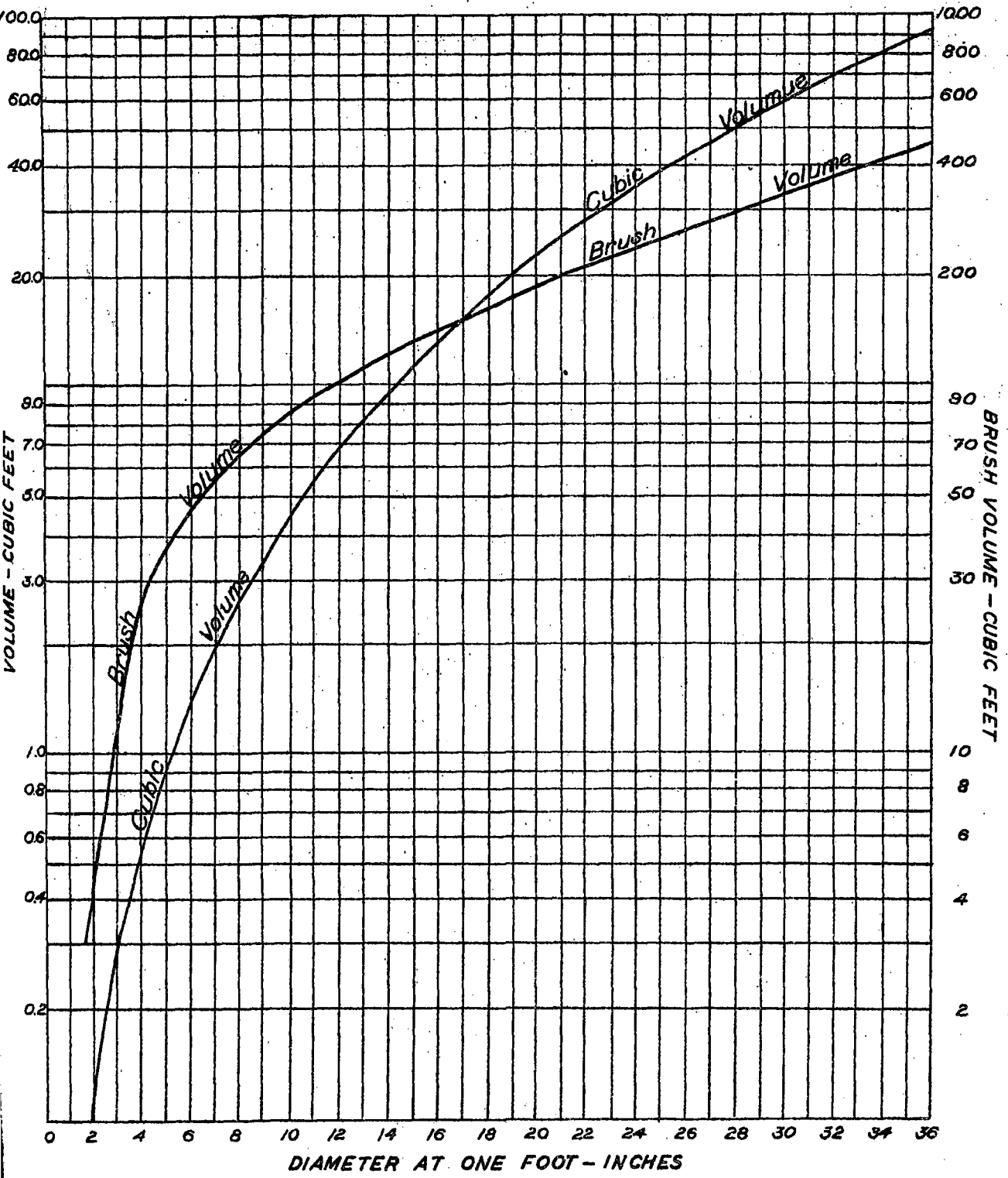


Figure 3. Volume Table for One-seed Juniper. Basis 1032 Trees, All Sites.

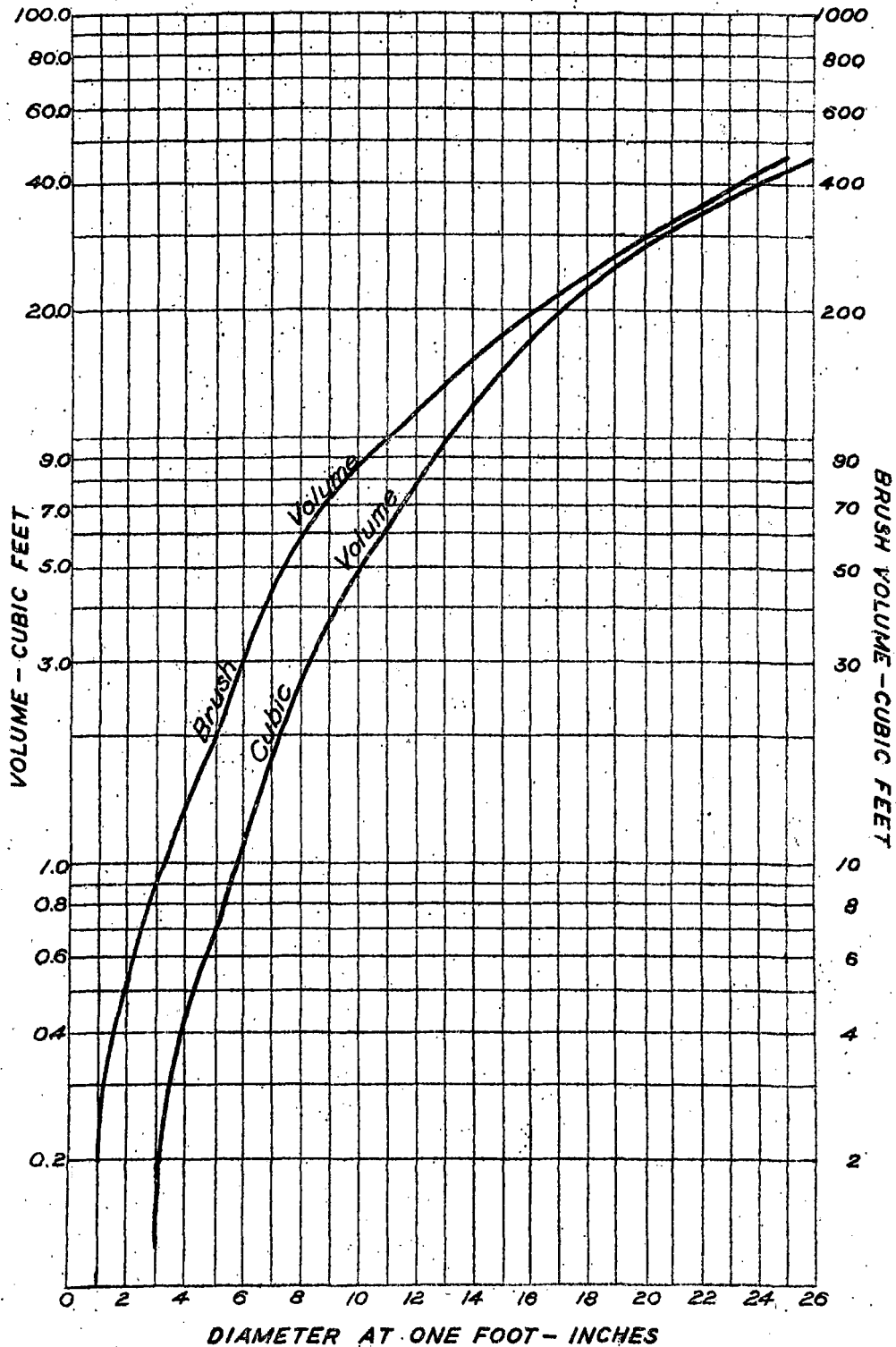


Figure 4. Volume Table for Rocky Mountain Red Cedar. Basis 289 trees, All Sites.

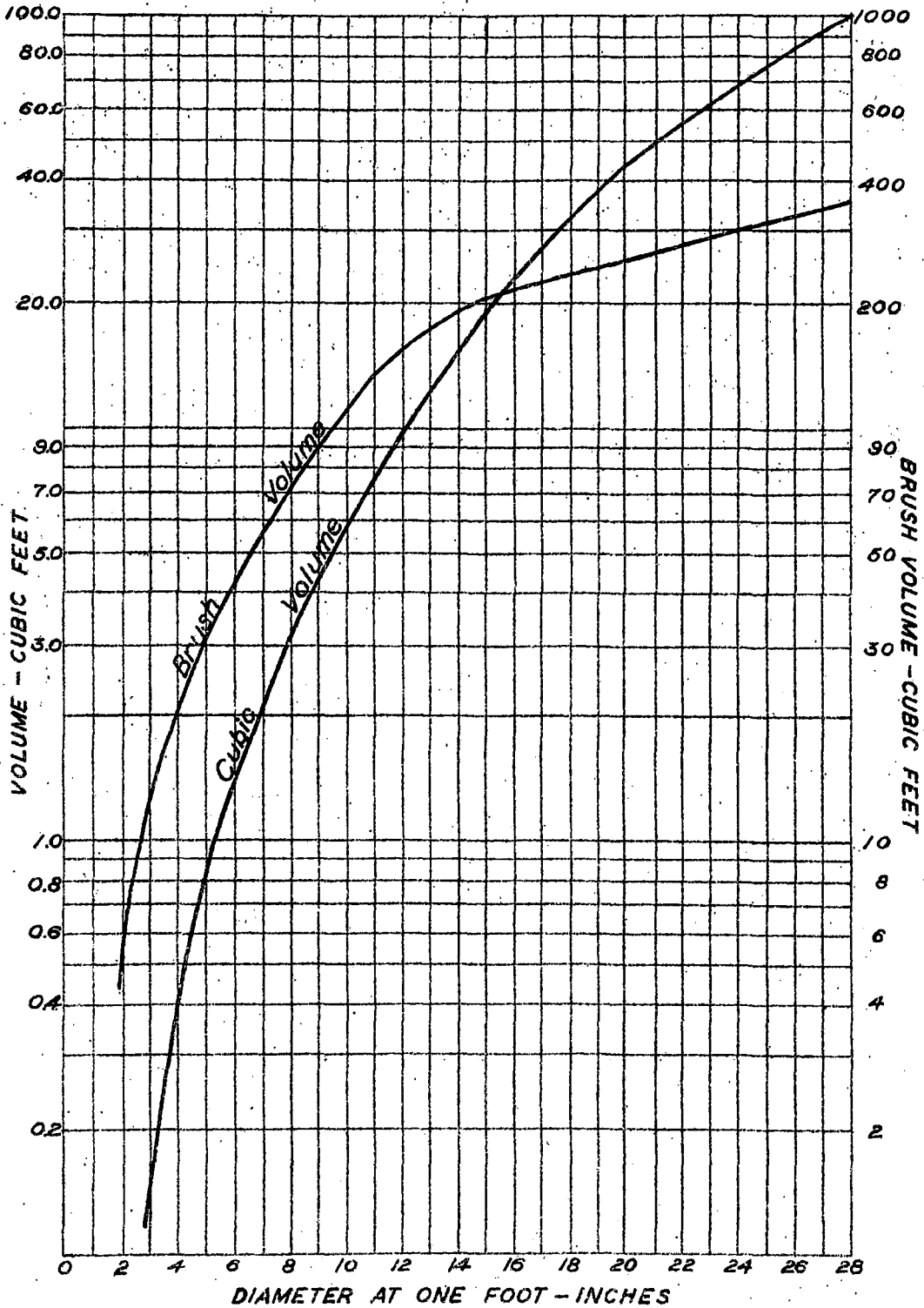


Figure 5. Volume Table for Pinon
Basis 1524 trees, All Sites.

Table 2.

Average Cord Volume Per Tree, Number of 4-foot Pieces Per Tree, Average Volume Per Piece, Number of Trees Required to Make One Cord, and Number of Pieces Per Cord. Basis 1032 trees.

One-Seed Juniper

Dia. at one- foot inches	Number of Trees Basis	Average Volume Per Tree Cord	Average Number of 4-Foot Pieces Per Tree	Average Volume Per Piece Cord	Number of Trees Per Cord	Number of Pieces Per Cord
1	1	---	---	---	---	---
2	6	0.0010	1.0	0.0010	1000	1000
3	36	0.0042	1.7	0.0026	238	405
4	67	0.0116	2.6	0.0040	86	224
5	82	0.0179	3.7	0.0048	56	207
6	91	0.0254	5.0	0.0051	39	195
7	72	0.0340	6.3	0.0054	29	183
8	92	0.0440	7.8	0.0058	23	179
9	97	0.0592	9.5	0.0062	17	161
10	76	0.0865	11.2	0.0072	12	134
11	58	0.1100	13.4	0.0082	9.1	122
12	55	0.1340	15.7	0.0084	7.5	118
13	47	0.1565	18.0	0.0086	6.4	115
14	50	0.1780	20.6	0.0088	5.6	115
15	39	0.1995	23.5	0.0088	5.0	117
16	34	0.2240	26.0	0.0088	4.5	117
17	23	0.2440	29.0	0.0090	4.1	117
18	14	0.2725	31.5	0.0092	3.7	117
19	16	0.3025	34.0	0.0094	3.2	109
20	15	0.3385	36.2	0.0097	3.0	109
21	7	0.3880	39.0	0.0100	2.6	101
22	8	0.4500	41.8	0.0108	2.2	92
23	11	0.5300	44.3	0.0120	1.9	84
24	5	0.6250	46.5	0.0130	1.6	74
25	5	0.6750	49.8	0.0135	1.5	74
26	6	0.7250	52.8	0.0135	1.4	74
27	4	0.7800	55.8	0.0136	1.3	73
28	1	0.8250	58.9	0.0136	1.2	71
29	4	0.8650	64.5	0.0137	1.2	77
30	1	0.8950	65.0	0.0137	1.1	72
31	4	0.9250	68.0	0.0137	1.1	75
32	1	0.9650	72.0	0.0138	1.0	72
33	0	1.0000	76.0	0.0138	1.00	76
34	1	1.0300	78.5	0.0139	0.97	76
35	0	1.0500	82.5	0.0139	0.95	78
36	3	1.0900	85.0	0.0140	0.92	78

Table 3.

Average Cord Volume Per Tree, Number of 4-Foot Pieces per Tree, Average Volume Per Piece, Number of Trees Required to Make One Cord, and Number of Pieces per Cord. Basis 289 Trees.

Rocky Mountain Red Cedar

Dia. One Foot Inches	Number of Trees Basis	Average Volume Per Tree Cord	Average Number of 4-Foot Pieces Per Tree	Average Volume Per Piece Cord	Number of trees per Cord	Number of Pieces Per Cord
1	---	---	---	---	---	---
2	---	---	---	---	---	---
3	8	0.0010	1.0	0.0010	1000	1000
4	19	0.0013	1.5	0.0030	233	349
5	29	0.0085	2.1	0.0040	118	248
6	43	0.0135	2.8	0.0047	74	207
7	20	0.0190	3.6	0.0053	53	191
8	19	0.0268	4.7	0.0058	37	174
9	31	0.0394	6.2	0.0064	25	155
10	19	0.0590	7.8	0.0075	17	133
11	27	0.0950	9.3	0.0100	11	102
12	14	0.1260	10.9	0.0124	7.9	86
13	11	0.1535	12.6	0.0125	6.5	81
14	19	0.1785	14.1	0.0126	5.6	80
15	6	0.2045	16.0	0.0126	4.9	78
16	8	0.2275	17.8	0.0126	4.4	78
17	6	0.2550	19.5	0.0127	3.9	76
18	2	0.2775	21.3	0.0127	3.6	77
19	2	0.3000	23.4	0.0127	3.3	77
20	0	0.3225	25.2	0.0128	3.1	78
21	1	0.3450	27.0	0.0128	2.9	78
22	1	0.3700	29.0	0.0128	2.7	78
23	0	0.3950	31.2	0.0129	2.5	78
24	3	0.4150	32.8	0.0129	2.4	79
25	1	0.4400	34.8	0.0129	2.3	80

Table 4.

Average Volume in Cords Per Tree, Number of 4-foot Pieces Per Tree, Average Volume per Piece, Number of Trees Required to Make One Cord, and Number of Pieces per Cord. Basis 584 trees.

Pinon

Dia. at one- foot inches	Number of Trees Basis	Average Volume Per Tree Cord	Average Number of 4-foot Pieces Per Tree	Average Volume Per Piece Cord	Number of Trees Per Cord	Number of Pieces Per Cord
1	4	0.0021	0.8	0.0014	475	594
2	40	0.0034	1.5	0.0023	268	402
3	56	0.0085	2.6	0.0032	120	312
4	61	0.0144	3.5	0.0039	75	262
5	67	0.0234	4.8	0.0046	48	230
6	67	0.0320	6.4	0.0052	35	237
7	54	0.0463	8.5	0.0058	22	187
8	41	0.0735	11.0	0.0064	11	121
9	35	0.1055	15.2	0.0069	7.7	117
10	21	0.1425	19.0	0.0074	6.0	114
11	19	0.1975	23.4	0.0078	4.9	115
12	12	0.2380	27.8	0.0080	4.2	117
13	16	0.2875	31.6	0.0084	3.7	117
14	6	0.3350	36.8	0.0088	3.1	114
15	4	0.3575	39.0	0.0089	2.9	112
16	2	0.4000	43.5	0.0090	2.6	113
17	2	0.4300	46.1	0.0092	2.4	111
18	2	0.4775	51.7	0.0094	2.2	114
19	3	0.5300	57.4	0.0097	2.0	115
20	1	0.5600	62.0	0.0098	1.9	118
21	1	0.6150	65.5	0.0100	1.7	111
22	0	0.6400	71.5	0.0101	1.6	115
23	0	0.7000	76.5	0.0103	1.5	115
24	0	0.7550	82.0	0.0105	1.3	107
25	0	0.8000	84.0	0.0106	1.2	100
26	0	0.8400	90.0	0.0108	1.1	99
27	1	0.9000	98.5	0.0109	1.0	98.5

F. - GROWTH

Growth is slow in the coniferous woodland type with but little variation in growth rate for individual trees between good and poor sites due to the all-aged character of coniferous woodland stands. Bands of wide and narrow rings are not uncommon but the variation is not large. Age is but relative in the three species as false rings are common and are identified in the field only with difficulty. Unfortunately, time was not available to make a study of false rings so they were not determined and were disregarded in the determination of age.

The all-aged nature of coniferous woodland stands prohibits the use of age in site determinations and in yield table construction. The tables and figures that are presented in this portion of the bulletin are based on all plots and trees. Local corrections may be necessary^o to provide usable data.

The following data applies to individual trees. Growth is maintained at a relatively even rate until the tree is 500 or more years old unless some adverse factor obtains. As the trees become older, they achieve sufficient dominance to receive some side light which probably accounts for maintenance of growth rate for an extremely long period of time (See Figure 6.)

It will be noticed that Rocky Mountain red cedar has the greatest preliminary diameter growth rate and the lowest terminal growth rate of any of the three species. The diameter, at one foot, growth rate increases rapidly until about the fortieth year, when having attained a rate of increase of 0.78 inch per decade it begins to decrease, falling

below the growth of pinon at about the 150th year and one-seed juniper in the 180th year. Pinon has an intermediate growth rate to the 140th year after which it exceeds both the junipers until the 250th year. At that point, it falls below the curve for one-seed juniper until the 350th year after which it regains ascendancy.

One-seed juniper is the slowest but has the most uniform diameter growth rate of the three species. Its diameter growth rate reaches a peak of 0.58 inch per decade at about the 60th year, then falls slowly until the 170th year after which the rate of diameter growth falls but 0.04 inch in over 300 years.

Diameter at one foot attained throughout the life of individual trees is relatively the same for all species with Rocky Mountain red cedar the only one showing any decided slowing down with age.

Total height growth is maintained throughout life, although for pinon and Rocky Mountain red cedar there is a slowing of height growth after the first fifty years. (See Figures 7, 8 and 9.)

One-seed juniper has an entirely different tendency. At first, height growth is relatively fast. It then decreases for about 250 years, after which there is another period of accelerated growth. The reasons underlying this condition have not been determined.

Tables 5, 6 and 7 are interesting, particularly when one compares mean annual and periodic annual increment.

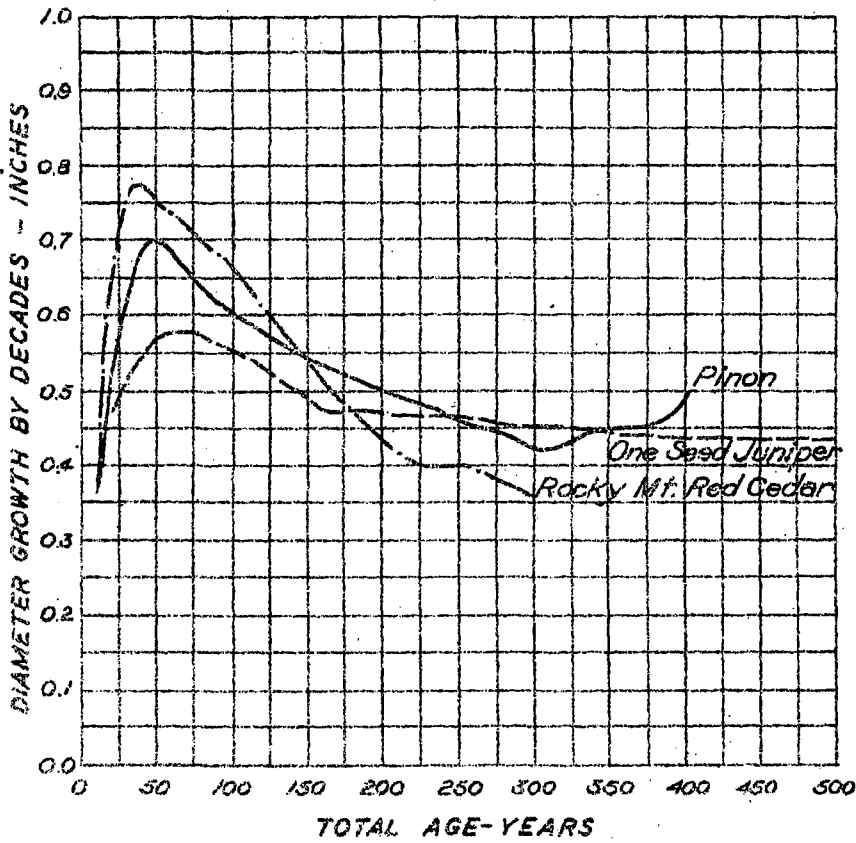


Figure 6. Growth of Pinon, One-seed Juniper, and Rocky Mountain Red Cedar. Diameter Growth at One Foot by Age and for Decades.

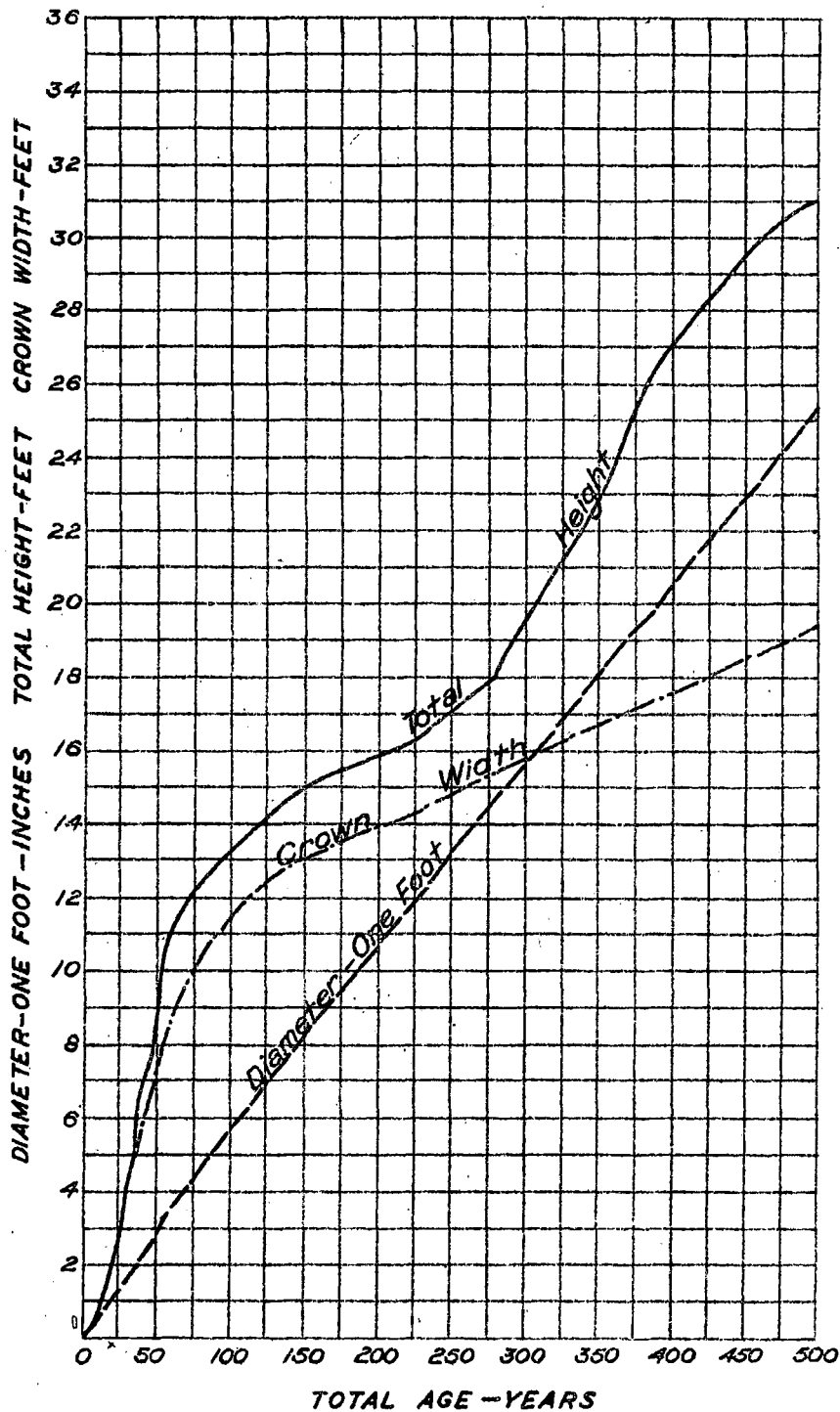


Figure 7. Growth of One-Seed Juniper.
Total Height, Crown Width and
Diameter at One Foot.

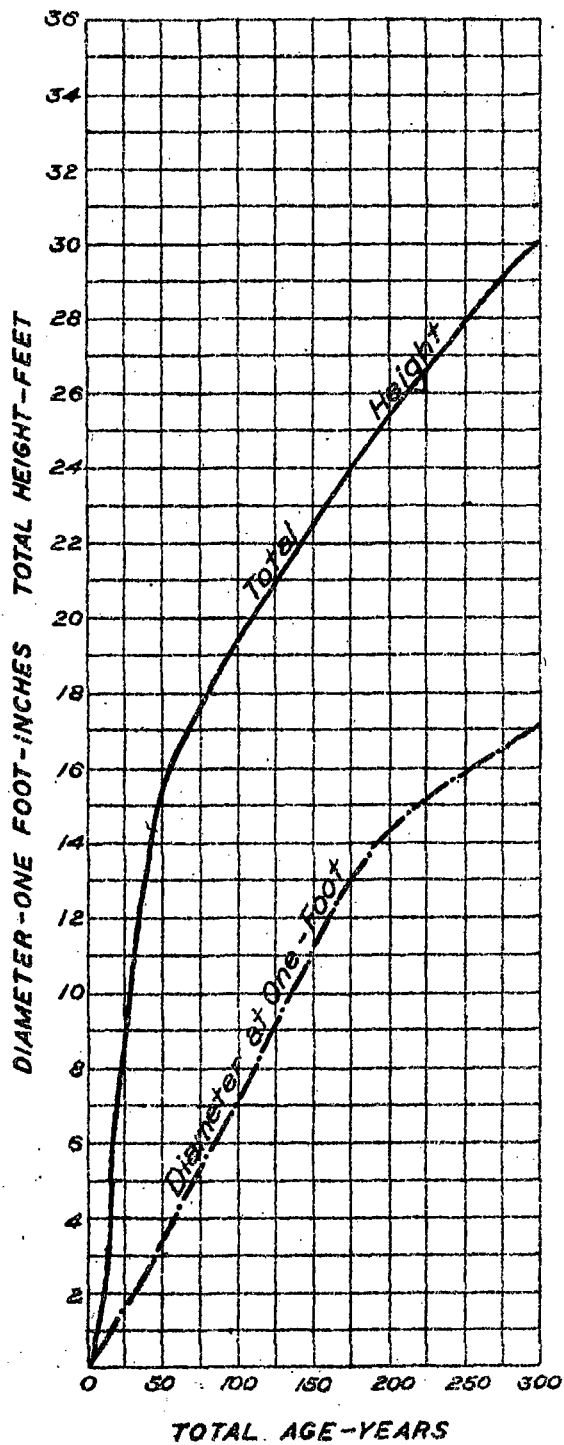


Figure 8. Growth of Rocky Mountain Red Cedar.
Total Height and Diameter at One Foot.

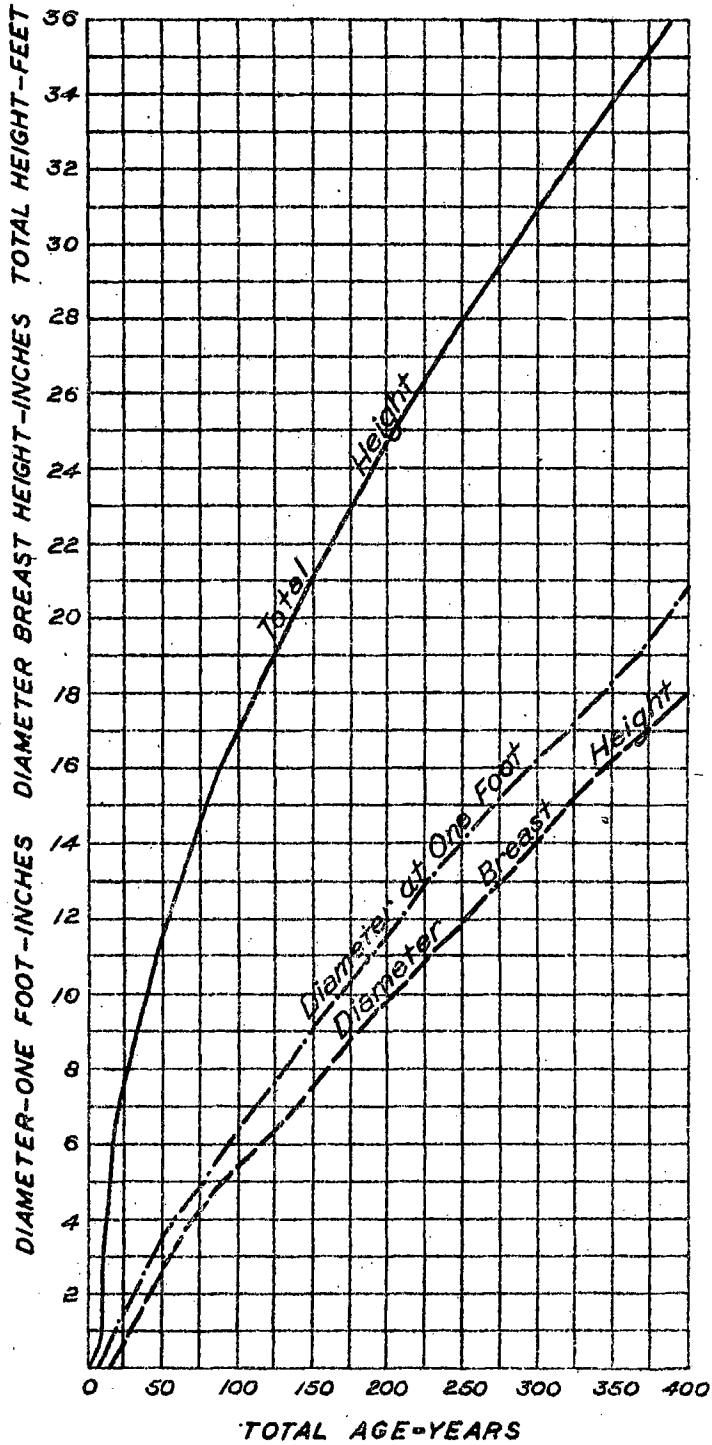


Figure 9. Growth of Pinon. Total Height, Diameter at One Foot, and Diameter at Breast Height.

Table 5. Growth of One-Seed Juniper

331 Trees Based on Age

Age Years	Dia. 1 ft. inches	Total Height Feet	Crown Width Feet	Cubic Volume Cu. ft.	M.A.I. on B.A. Cu. ft.	P.A.I. on B.A. Cu. ft.	Dia. growth by decades inches
13	0.0	1.0	1.0	---	---	---	0.42
20	0.7	2.0	2.0	---	---	---	0.47
30	1.4	3.9	3.8	---	---	---	0.52
40	2.2	6.2	5.6	0.18	0.004	0.012	0.55
50	2.9	8.7	7.3	0.30	0.006	0.014	0.57
60	3.5	10.9	8.8	0.45	0.008	0.017	0.58
70	4.0	11.8	9.8	0.64	0.010	0.021	0.58
80	4.6	12.4	10.4	0.87	0.012	0.024	0.57
90	5.1	13.0	11.0	1.14	0.013	0.027	0.56
100	5.6	13.3	11.5	1.48	0.015	0.029	0.55
110	6.2	13.7	12.0	1.80	0.017	0.032	0.54
120	6.7	14.0	12.3	2.20	0.018	0.034	0.53
130	7.3	14.4	12.6	2.58	0.019	0.036	0.51
140	7.8	14.7	12.8	2.95	0.020	0.037	0.50
150	8.2	14.9	13.0	3.32	0.021	0.038	0.49
160	8.8	15.1	13.2	3.64	0.022	0.040	0.48
170	9.2	15.3	13.4	3.98	0.023	0.042	0.47
180	9.8	15.5	13.6	4.33	0.024	0.044	0.47
190	10.3	15.7	13.8	4.70	0.025	0.046	0.47
200	10.8	15.9	13.9	5.17	0.026	0.049	0.47
210	11.3	16.0	14.0	5.65	0.028	0.053	0.47
220	11.8	16.2	14.2	6.28	0.029	0.059	0.47
230	12.3	16.6	14.5	6.90	0.030	0.063	0.46
240	12.8	17.0	14.7	7.45	0.032	0.069	0.46
250	13.3	17.2	14.9	8.30	0.033	0.075	0.46
260	13.8	17.5	15.1	9.00	0.036	0.083	0.46
270	14.3	17.7	15.3	10.15	0.038	0.094	0.46
280	14.8	18.0	15.5	11.00	0.040	0.103	0.46
290	15.4	19.0	15.7	12.00	0.042	0.112	0.46
300	15.8	19.7	15.9	13.30	0.044	0.120	0.45
320	16.8	21.0	16.2	17.00	0.050	0.132	0.45
340	17.8	22.5	16.6	19.80	0.056	0.148	0.45
360	18.7	24.4	17.0	23.00	0.062	0.160	0.45
380	19.7	26.0	17.3	26.80	0.068	0.171	0.44
400	20.6	27.3	17.7	30.50	0.075	0.194	0.44
420	21.5	28.1	18.0	34.25	0.082	0.215	0.43
440	22.5	29.0	18.3	39.00	0.088	0.234	0.43
460	23.5	29.9	18.6	44.75	0.094	0.254	0.43
480	24.4	30.6	19.0	49.00	0.100	0.275	0.43
500	25.4	31.2	19.2	54.00	0.108	0.290	0.43

Table 6. Growth of Rocky Mountain Red Cedar

96 Trees Based on Age.

Age Years	D. 1 ft. inches	D. 1 ft. ib inches	Cubic Volume cu.ft.	M.A.I. based on B.A. cu.ft.	P.A.I. based on B.A. cu.ft.	Dia. growth per decade inches	Total Height feet
10	0.4	0.1	---	---	---	0.40	2.8
20	1.0	0.7	0.09	0.005	0.009	0.66	6.7
30	1.8	1.4	0.18	0.006	0.012	0.74	10.5
40	2.9	2.2	0.30	0.007	0.015	0.78	13.5
50	3.5	2.9	0.44	0.009	0.018	0.75	15.3
60	4.1	3.7	0.61	0.010	0.021	0.73	16.3
70	4.9	4.4	0.70	0.011	0.024	0.71	17.0
80	5.7	5.1	1.03	0.013	0.028	0.70	17.9
90	6.5	5.8	1.27	0.014	0.032	0.68	18.5
100	7.1	6.4	1.56	0.016	0.036	0.66	19.2
110	7.8	7.1	1.90	0.017	0.040	0.63	20.0
120	8.6	7.8	2.30	0.019	0.046	0.60	20.5
130	9.5	8.5	2.73	0.021	0.052	0.58	21.2
140	10.2	9.1	3.24	0.023	0.059	0.56	21.9
150	11.1	9.7	3.82	0.025	0.069	0.53	22.5
160	12.0	10.2	4.53	0.028	0.077	0.51	23.0
170	12.8	10.7	5.40	0.032	0.088	0.49	23.5
180	13.3	11.1	6.35	0.035	0.100	0.46	24.2
190	13.9	11.6	7.35	0.039	0.116	0.44	24.7
200	14.4	12.1	8.50	0.043	0.130	0.43	25.3
210	14.7	12.5	10.00	0.048	0.150	0.42	25.7
220	15.0	12.9	11.45	0.052	0.170	0.41	26.3
230	15.2	13.3	13.30	0.058	0.193	0.40	26.7
240	15.5	13.7	15.20	0.066	0.215	0.40	27.3
250	15.8	14.1	17.80	0.071	0.240	0.40	27.7
260	16.1	14.5	20.80	0.080	0.268	0.39	28.3
270	16.3	14.8	24.50	0.091	0.295	0.38	28.7
280	16.6	15.2	27.75	0.097	0.330	0.38	29.0
290	16.8	15.5	31.15	0.107	0.400	0.37	29.5
300	17.0	15.9	37.00	0.123	---	0.36	30.0

Table 7. Growth of Pinon

584 Trees. Based on Age.

Age Years	D. 1 ft. inches	D.B.H. inches	Total Height feet	Cu. vol. Cu. feet	M.A.I. on B.A. cu.ft.	P.A.I. on B.A. cu.ft.	Dia. growth per decade inch
10	0.0	0.0	1.0	---	---	---	0.36
20	1.2	0.2	6.8	---	---	---	0.52
30	1.9	0.8	8.6	---	---	---	0.63
40	2.6	1.6	10.1	0.15	0.004	0.024	0.69
50	3.3	2.5	11.4	0.39	0.009	0.031	0.70
60	4.0	3.4	12.7	0.75	0.013	0.037	0.68
70	4.6	4.0	13.8	1.12	0.016	0.042	0.65
80	5.2	4.5	15.0	1.50	0.019	0.048	0.63
90	5.7	5.0	16.0	2.00	0.022	0.053	0.62
100	6.3	5.4	16.8	2.55	0.026	0.060	0.60
110	6.8	5.8	17.7	3.20	0.029	0.065	0.59
120	7.4	6.2	18.6	4.00	0.033	0.073	0.58
130	8.0	6.5	19.4	4.60	0.035	0.078	0.56
140	8.5	7.0	20.3	5.40	0.039	0.084	0.55
150	9.1	7.5	21.0	6.25	0.042	0.088	0.54
160	9.6	8.0	21.9	7.10	0.044	0.098	0.53
170	10.1	8.5	22.7	8.10	0.048	0.104	0.52
180	10.6	9.0	23.3	9.20	0.051	0.110	0.52
190	11.2	9.4	24.0	10.30	0.054	0.117	0.51
200	11.6	9.8	24.7	11.50	0.058	0.123	0.50
210	12.1	10.2	25.3	12.70	0.061	0.130	0.50
220	12.6	10.5	26.2	14.00	0.064	0.137	0.49
230	13.0	10.9	26.8	15.50	0.067	0.143	0.48
240	13.5	11.4	27.4	17.00	0.071	0.148	0.47
250	14.0	11.8	28.0	18.40	0.074	0.150	0.46
260	14.5	12.2	28.5	19.80	0.076	0.160	0.46
270	14.9	12.7	29.3	21.40	0.079	0.165	0.45
280	15.4	13.2	29.8	23.00	0.082	0.172	0.44
290	15.8	13.6	30.5	24.70	0.085	0.180	0.43
300	16.2	14.0	31.0	26.50	0.088	0.185	0.42
310	16.6	14.4	31.5	28.00	0.090	0.198	0.42
320	17.0	14.8	32.2	30.60	0.096	0.204	0.43
330	17.4	15.3	32.8	32.50	0.099	0.220	0.44
340	17.8	15.7	33.3	34.80	0.102	0.240	0.44
350	18.3	16.1	33.7	37.20	0.106	0.260	0.44
360	18.7	16.5	34.5	40.00	0.111	0.310	0.44
370	19.2	17.0	35.0	44.10	0.119	0.410	0.45
380	19.6	17.3	35.6	50.00	0.132	0.580	0.45
390	20.2	17.5	36.0	57.00	0.146	0.800	0.46
400	20.7	17.8	36.4	65.00	0.163	---	0.50

The following discussion applies to stand conditions: Instead of using total age as a basis for growth, diameter at one foot was substituted due to the all-aged nature of the stands. For all practical purposes, diameter at one foot inside bark is linear. Total height varies somewhat between species. For one-seed juniper, height growth is rapid until the tree is 3 inches in diameter. After that, growth is greatly reduced and nearly linear.

For Rocky Mountain red cedar, the most rapid height growth is attained prior to the time this species attains a stump diameter of one inch. After this period, growth diminishes until a diameter of about five inches is reached, at which time a period of accelerated growth starts that continues until a diameter of about 18 inches is attained.

For pinon, height growth is much slower than for Rocky Mountain red cedar but is maintained for a longer period.

These relationships are illustrated in Figures 10, 11, 12 and 13.

Growth rate in per cent based on basal area at one foot is greatest for Rocky Mountain red cedar and lowest for one-seed juniper until the individual tree attains a size of about 14 inches in diameter at one foot. At this point, pinon exceeds Rocky Mountain red cedar and at 16 inches one-seed juniper. From then on, pinon maintains an almost even rate of growth while one-seed juniper has only a slightly diminishing rate of growth after reaching a size of 14 inches at the stump. The rate of growth of Rocky Mountain red cedar decreases more rapidly than the other species, terminating at a diameter of 25 inches with a

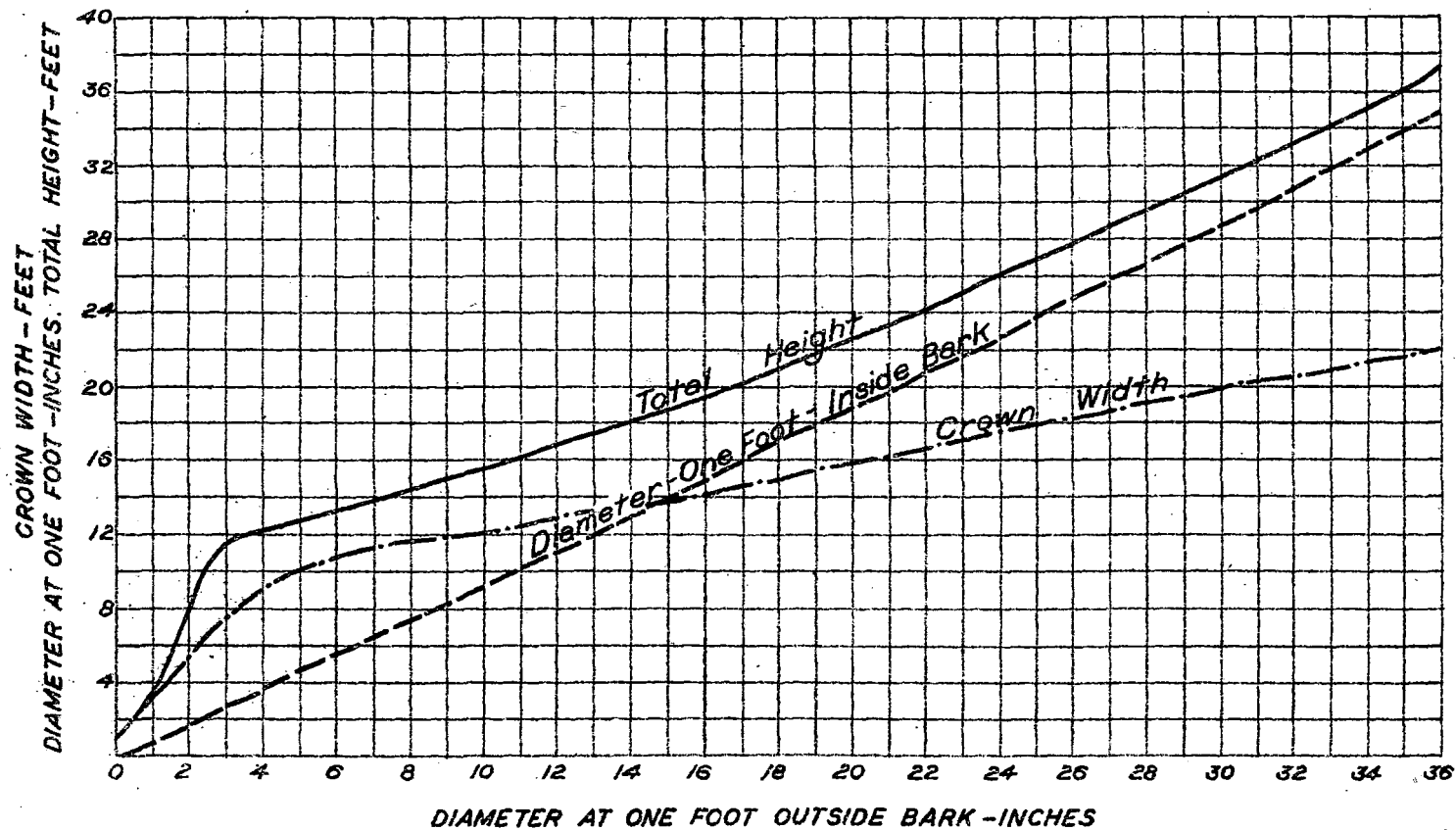


Figure 10. Growth of One-Seed Juniper. Basis, Diameter at One Foot.

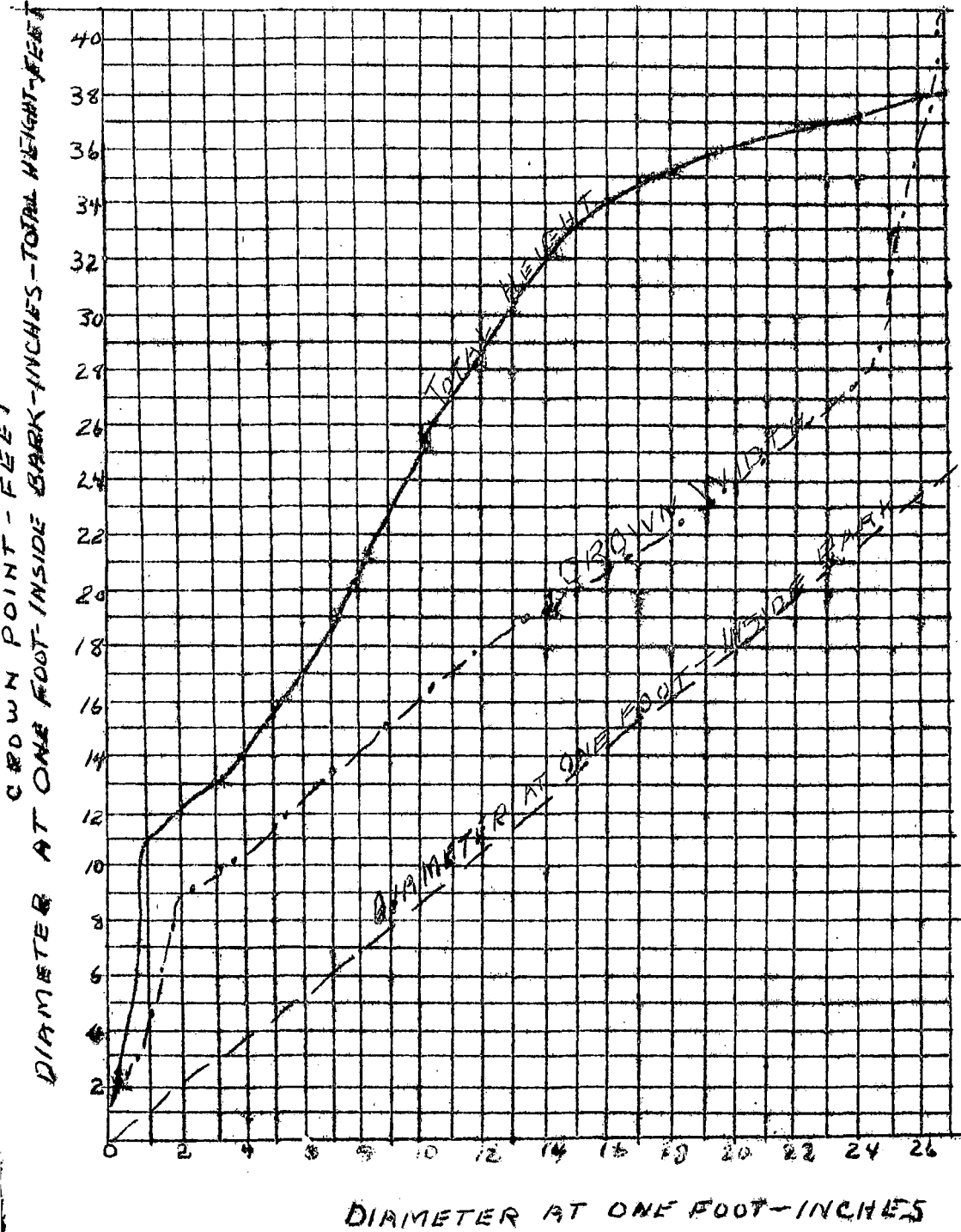


Figure 11. Growth of Rocky Mountain Red Cedar.
Basis Diameter at One Foot.

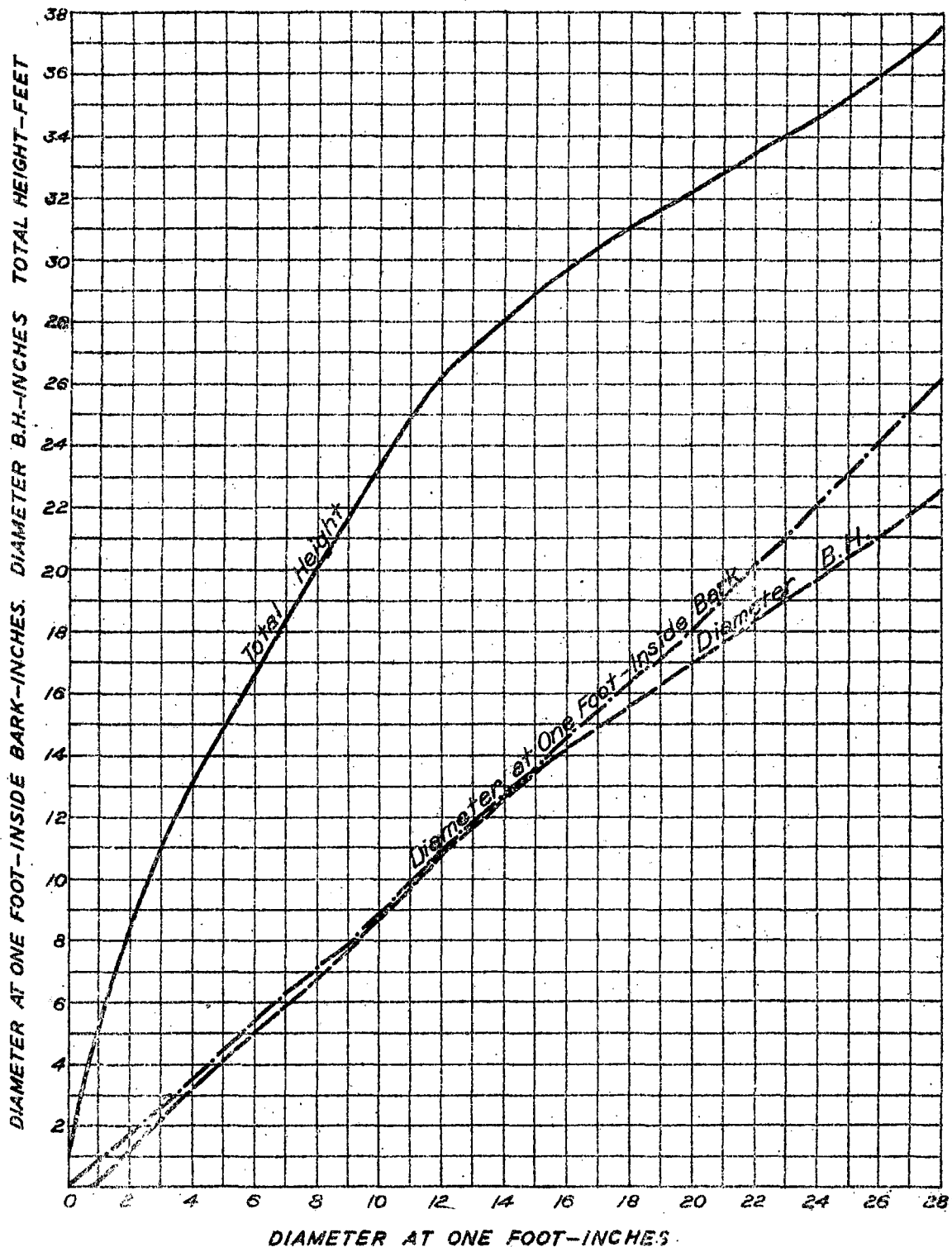


Figure 12. Growth of Pinon, Basis, Diameter at One Foot.

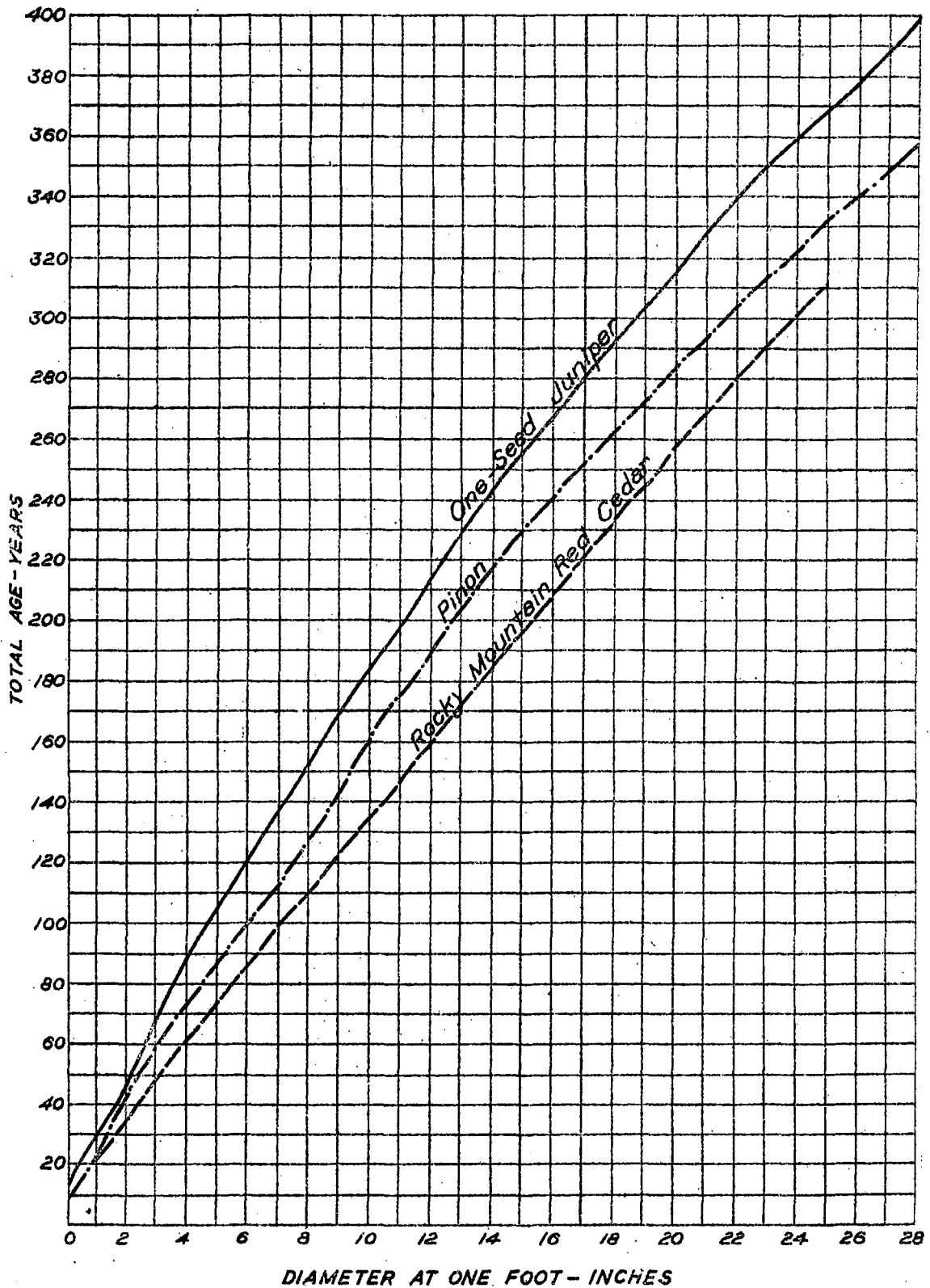


Figure 13. Growth of One-Seed Juniper, Rocky Mountain Red Cedar, and Pinon. Basis, Diameter at One Foot.

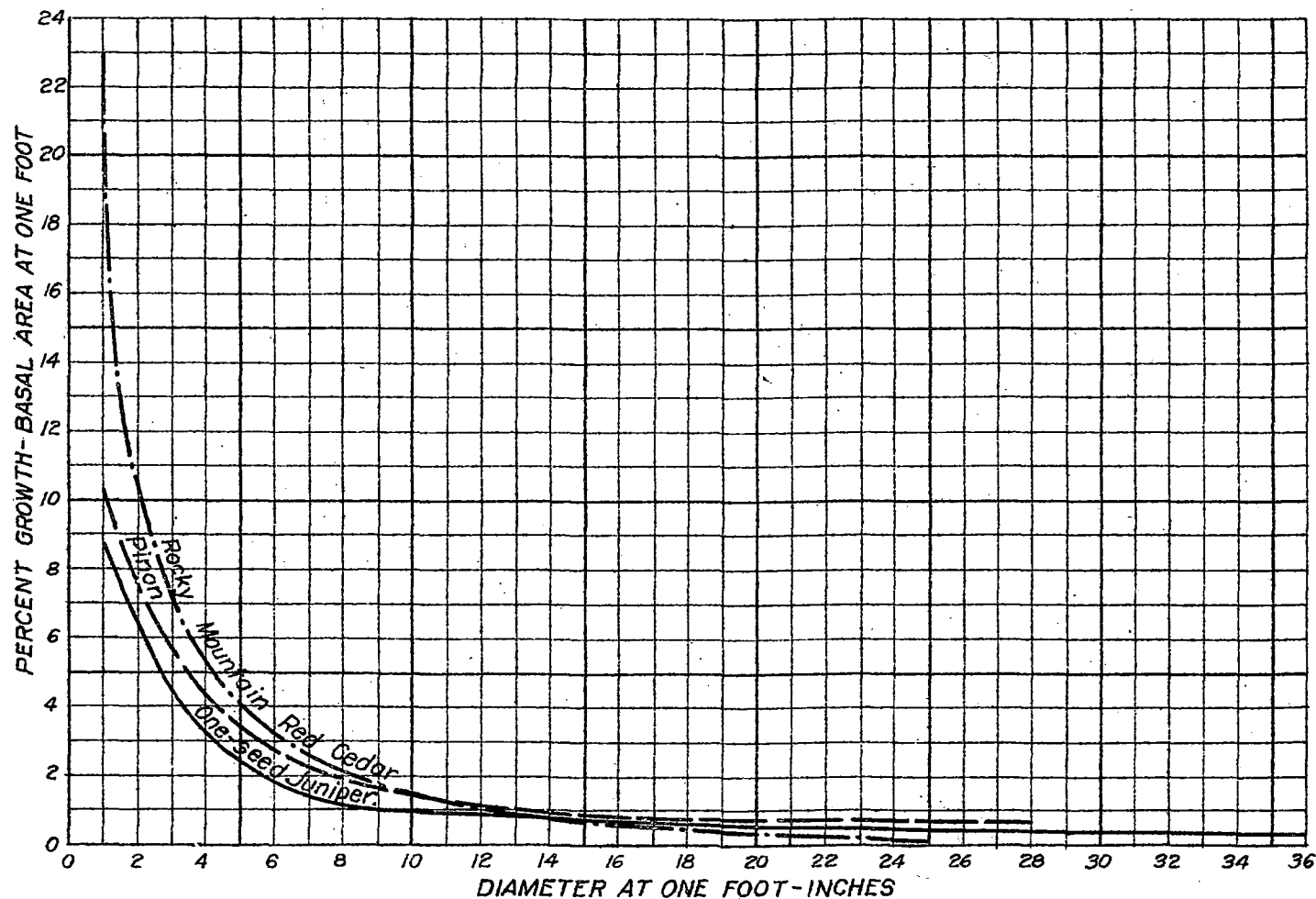


Figure 14. Per Cent Growth for Pinon, One-Seed Juniper and Rocky Mountain Red Cedar. Basis, Basal Area at One Foot.

Table 8. Growth of One-Seed Juniper

331 Trees. Based on Diameter at one Foot.

D. 1 ft. ob inches	D. 1 ft. ib inches	Age Years	Height Feet	Crown Width feet	No. 4' Pieces	Cu. Vol. Cu.ft.	Brush Vol. Cu.ft.	M.A.I. on B.A. Cu.ft.	P.A.I. on B.A. Cu.ft.	% Growth on B.A.
0	0.0	13	1.0	1.0	---	---	---	---	---	---
1	0.8	28	3.8	3.5	---	---	---	---	---	8.8
2	1.7	49	8.6	5.8	---	---	4.5	---	---	6.5
3	2.6	68	11.6	7.5	1.7	0.23	10.4	0.003	0.009	4.5
4	3.6	87	12.3	9.0	3.6	0.65	26.0	0.007	0.015	3.3
5	4.5	104	12.6	10.0	5.2	1.13	36.5	0.011	0.022	2.5
6	5.4	121	13.0	10.7	6.6	1.60	45.8	0.013	0.029	1.8
7	6.4	139	13.6	11.2	8.0	2.12	54.0	0.015	0.036	1.4
8	7.2	154	14.0	11.5	9.3	2.74	64.0	0.018	0.043	1.2
9	8.2	170	14.7	11.7	10.8	3.55	72.5	0.021	0.053	1.1
10	9.2	185	15.3	12.0	12.3	4.46	82.5	0.024	0.064	1.0
11	10.0	200	15.8	12.5	14.2	5.50	91.0	0.028	0.077	0.9
12	11.0	214	16.4	12.9	16.5	7.22	100.0	0.036	0.092	0.9
13	12.0	229	17.0	13.3	19.0	8.95	110.0	0.039	0.110	0.9
14	12.8	241	17.8	13.6	21.6	10.95	120.0	0.045	0.128	0.8
15	13.9	255	18.7	14.0	24.3	13.00	128.0	0.051	0.145	0.8
16	14.8	267	19.3	14.4	27.2	15.50	140.0	0.058	0.165	0.7
17	15.8	280	20.0	14.8	30.0	18.25	150.0	0.065	0.188	0.7
18	16.8	292	20.8	15.2	33.5	21.10	162.0	0.072	0.210	0.7
19	17.8	303	21.7	15.5	37.0	24.00	175.0	0.079	0.236	0.6
20	18.8	317	22.4	15.8	40.8	27.50	187.0	0.087	0.258	0.5
21	19.8	325	23.1	16.3	44.2	31.00	197.0	0.095	0.285	0.5
22	20.8	340	24.0	16.6	48.5	35.00	210.0	0.103	0.320	0.4
23	21.8	350	25.0	17.0	54.0	39.40	223.0	0.113	0.345	0.4
24	22.6	360	25.8	17.4	59.0	44.00	236.0	0.122	0.370	0.4
25	23.6	368	26.7	17.7	64.0	48.25	250.0	0.131	0.400	0.4
26	24.5	378	27.5	18.1	69.5	53.10	265.0	0.140	0.438	0.4
27	25.5	386	28.3	18.5	74.5	58.80	282.5	0.152	0.475	0.4
28	26.5	400	29.4	18.9	80.0	65.00	300.0	0.163	0.518	0.4
29	27.5	408	30.2	19.3	86.5	70.00	317.5	0.171	0.562	0.4
30	28.5	418	31.3	19.7	92.4	77.00	332.5	0.184	0.608	0.4
31	29.5	425	32.2	20.0	99.5	82.50	350.0	0.194	0.660	0.4
32	30.5	437	33.4	20.4	105.0	90.00	370.0	0.206	0.710	0.4
33	31.5	444	34.0	20.8	110.0	95.25	390.0	0.214	0.760	0.4
34	32.5	453	35.0	21.2	118.0	103.50	412.0	0.228	0.820	0.4
35	33.4	460	36.0	21.5	127.5	113.00	430.0	0.248	0.885	0.4
36	34.4	467	36.9	21.8	134.0	119.20	450.0	0.256	0.950	0.4

Table 9.

Growth of Rocky Mountain Red Cedar -

96 Trees. Based on Diameter at One Foot.

Dia. 1 ft. ob inches	Dia. 1 ft. ib inches	Age Years	Height Feet	Crown Width Feet	Volume cu.ft.	Brush Volume Cu.ft.	% Growth B.A.
0	---	8	1.0	---	---	---	---
1	0.90	22	10.9	7.6	---	2.2	23.0
2	1.80	36	11.9	8.4	---	5.3	10.2
3	2.70	49	13.0	9.2	0.15	8.7	7.2
4	3.60	62	14.3	9.9	0.37	13.0	5.3
5	4.50	74	15.6	10.7	0.68	19.7	4.0
6	5.40	86	17.2	11.6	1.13	30.0	3.2
7	6.30	99	19.0	12.5	1.72	43.8	2.6
8	7.20	110	20.5	13.5	2.57	58.3	2.1
9	8.10	123	22.1	14.5	3.60	72.5	1.7
10	9.00	136	23.4	15.4	4.80	85.5	1.4
11	9.85	148	24.5	16.4	6.35	100.0	1.2
12	10.75	159	25.4	17.4	8.00	117.5	1.0
13	11.65	170	26.3	18.4	9.85	132.5	0.9
14	12.50	185	27.0	19.5	12.00	152.0	0.8
15	13.40	197	27.9	20.6	13.75	172.0	0.7
16	14.30	208	28.7	21.8	15.75	195.0	0.6
17	15.20	220	29.8	23.0	17.40	220.0	0.5
18	16.15	235	30.2	24.4	19.75	242.0	0.5
19	17.05	246	30.7	25.8	21.75	270.0	0.4
20	18.00	257	31.1	27.2	24.40	295.0	0.4
21	18.95	268	31.5	28.9	26.30	325.0	0.3
22	19.90	278	31.9	30.5	28.80	360.0	0.3
23	20.85	291	32.3	32.3	30.90	390.0	0.2
24	21.80	303	32.8	34.1	33.50	420.0	0.2
25	22.75	311	33.2	36.0	35.50	455.0	0.1

Table 10. Growth of Pinon -

584 Trees. Based on Diameter at One Foot.

D. 1 ft. ob inches	D. 1 ft. ib inches	Age Years	D.B.H. ob inches	Height feet	No. 4' pieces	Vol. cu. ft.	Brush Vol. cu. ft.	% Growth B.A.
0	0.0	9	0.0	1.0	----	----	----	----
1	0.8	24	0.2	5.2	----	----	----	10.3
2	1.8	42	1.2	8.3	----	----	5.8	7.5
3	2.6	58	2.1	10.5	1.4	0.24	10.2	5.6
4	3.4	73	3.2	13.0	2.5	0.53	21.7	4.2
5	4.5	86	4.0	14.6	3.4	0.85	30.0	3.3
6	5.5	100	5.0	16.7	4.8	1.47	42.5	2.7
7	6.3	112	5.8	18.4	6.6	2.24	55.0	2.3
8	7.1	127	6.7	20.0	8.8	3.35	70.0	1.9
9	7.9	143	7.8	21.9	12.5	5.20	94.2	1.7
10	8.8	160	8.9	23.4	16.0	7.50	115.0	1.4
11	9.7	176	9.9	25.0	21.2	10.00	136.0	1.2
12	10.7	191	10.9	26.0	25.3	12.85	153.0	1.1
13	11.9	203	11.7	27.2	28.6	15.28	172.0	1.0
14	12.7	216	12.5	28.0	31.7	18.00	185.0	0.9
15	13.5	229	13.4	29.0	32.8	21.15	203.0	0.8
16	14.3	240	14.1	29.7	37.0	23.75	214.0	0.8
17	15.3	251	14.8	30.3	38.7	26.00	224.0	0.7
18	16.1	261	15.4	30.8	40.9	28.35	232.0	0.7
19	17.0	272	16.2	31.6	43.2	31.40	242.0	0.7
20	17.9	283	16.9	32.0	45.0	34.25	252.0	0.7
21	18.9	293	17.5	32.7	47.0	37.40	262.0	0.7
22	19.9	303	18.2	33.4	50.0	40.00	274.0	0.7
23	20.9	312	18.9	33.9	53.2	43.50	284.0	0.7
24	22.0	321	19.6	34.7	56.0	47.20	300.0	0.7
25	23.1	330	20.3	35.5	59.0	50.85	308.0	0.7
26	24.1	339	20.9	36.0	61.9	53.75	317.0	0.7
27	25.1	348	21.6	36.8	65.5	58.40	332.0	0.7
28	26.1	357	22.4	37.5	70.2	62.80	350.0	0.7

rate of 0.1 per cent. These relationships can be seen in figure 14.

All growth is gross as no attempt was made to determine net growth or net growth rates.

G. - COMPOSITION OF WOODLAND STANDS

An analysis of the 39 plots constituting the basic data for this study shows the following average composition based on basal area at stump height for trees over 4.5 foot high.

Table 11.

Composition of 39 Plots by Basal Area at Stump Height.

Species	Per cent
Pinon	49.3
One-seed juniper	46.8
Rocky Mt. red cedar	3.4
Ponderosa pine	0.3
Gambel oak	0.2
Total	100.0%

Through trial using 60 per cent of the basal area for trees over 4.5 high as a basis for type determinations, plot distribution by types appears as follows:

1. 15 Plots in the juniper type.
2. 13 Plots in the pinon type.
3. 11 Plots in the pinon-juniper type.

From the standpoint of available data, it is believed that a percentage of 60 should form the basis for type delineations for these

species. Using 80 per cent as a basis gave relatively few plots in the pinon or juniper type, most of the plots falling in the combined pinon-juniper type.

H. - DISTRIBUTION BY TREE CLASSES

All green living trees were recorded as to dominance and by age groupings as over-mature, mature, immature, and reproduction. These are relative classes as determined by field examination. Records were kept of the number of dead trees, trees that had been cut and trees partially cut. The following data does give a good picture of distribution based on dominance. See Table 12 for composition of Woodland Types by Tree Classes and Number of Trees Per Acre.

1. Dominants. An average of eight dominants, all species, were found per acre constituting 2 per cent of the total living trees. Some of the largest junipers could only be classed as intermediate due to their position in the crown canopy. Some plots had no dominant trees while others had as many as forty per acre. For all plots 45 per cent of the dominants were juniper and 55 per cent pinon, the percentage varying by types.

2. Co-Dominants. An average of 32 co-dominants, all species, were found per acre constituting about 8 per cent of the stand. All plots were found to have trees in this class ranging from 3 to as high as 115 per acre. More were found in the pinon type than in other types. Forty per cent of the co-dominants were junipers and 60 per cent pinon. This class had less members in the pinon-juniper type or 4.5 per cent of the total stand.

3. Intermediates. This class represented the bulk of the trees, averaging 334 per acre of all species. As many as 1108 intermediates per acre were found in the mixed type. Junipers constituted 38 per cent of this class and pinon 62 per cent. In terms of numbers of trees intermediates made up 82 per cent of the average stand over 4.5 feet in height.

4. Suppressed. This class represented 8 per cent of the live trees, averaging 32 per acre. All plots contained some trees in this class, one plot having 155 trees per acre or over 10 per cent of the stand. Apparently junipers are less subject to suppression in mixed stands than pinon since of the total number 65 per cent were pinon and 35 per cent juniper.

5. Reproduction. While three height classes were applied in collecting field data, they were consolidated for this report. Of the total stand, reproduction constituted about 35 per cent of the total living trees or about 250 per acre, all species. Variations per acre ran from 10 in an open juniper stand to 1140 in a pinon type of greater than average density. Thirty per cent of the reproduction was juniper and 70 per cent pinon.

Where the plots are segregated by types it is found that the 15 juniper plots have 37 per cent juniper and 63 per cent pinon reproduction. The mixed type has 33 per cent and the pinon type 21 per cent juniper reproduction.

The juniper plots contained the fewest seedlings, 135 per acre.

The mixed type had the largest average number of seedlings per acre, or 353. The pinon type averaged 295 per acre. As would be expected, the juniper type supports the fewest seedlings, 31% of all trees. Reproduction constitutes forty per cent of all trees in the pinon type.

6. Mortality. A tally was kept of all standing dead trees found on each plot. For all plots and species there was an average of 23 dead trees per acre. Of this average, 7 or 30 per cent were one-seed juniper and 16 or 70 per cent were pinon. Variations in number of dead trees from none to 115 per acre were found. Given similar stand conditions the number of dead trees present is naturally an index to the degree of use.

7. Cutting. Sample plots were selected in those portions of the coniferous woodland stands where past and present cutting has been at a minimum. However, all but six plots gave evidence of past cutting of entire trees or portions thereof.

For all plots there was an average of 17 cut trees per acre, half pinon and half juniper. Located in an area of heavy use, one plot showed 75 trees cut per acre.

8. Total Stand. The composite stand for the 39 plots averaged about 700 trees per acre of which 36 per cent were reproduction, 2 per cent cut and removed, 3 per cent dead; the remaining 59 per cent representing the living stand over 4.5 feet in height. The three types show considerable departure from the average. The pinon type averages about 735 trees per acre. The mixed type 980 and the juniper type 460 trees per acre.

Table 13 presents a comparison of stand composition by types, basal area, number of trees and cubic volume.

Table 12. Composition of Woodland Types
by Tree Classes and Number of Trees per Acre

Tree Class	Woodland Type							
	Juniper		Mixed		Pinon		Composite	
	Juniper	Pinon	Juniper	Pinon	Juniper	Pinon	Juniper	Pinon
Dominant	2.9	1.7	5.5	7.9	3.0	5.6	3.7	4.7
	4.6		13.4		8.6		8.4	
Codominant	14.2	7.5	9.4	18.6	14.0	33.2	12.8	19.5
	21.7		28.0		47.2		32.3	
Intermediate	119.5	118.7	206.4	287.8	63.6	243.8	125.8	208.2
	238.2		494.2		307.4		334.0	
Suppressed	8.6	19.9	15.4	24.9	10.0	20.9	11.0	21.0
	28.5		40.3		30.9		32.0	
Dead	8.3	14.6	10.2	15.3	4.3	16.9	7.5	15.5
	22.9		25.5		21.2		23.0	
Cut	3.6	3.4	16.7	6.7	7.6	15.0	8.6	8.2
	7.0		23.4		22.6		16.8	
Total	157.1	165.8	263.6	361.2	102.5	335.4	169.4	277.1
	322.9		624.8		437.9		446.5	
Reproduction	49.4	85.7	118.0	235.0	63.3	231.2	73.3	176.7
	135.1		353.0		294.5		250.0	
Grand Total	206.5	251.5	381.6	596.2	165.8	566.6	242.7	453.8
	458.0		977.8		732.4		696.5	

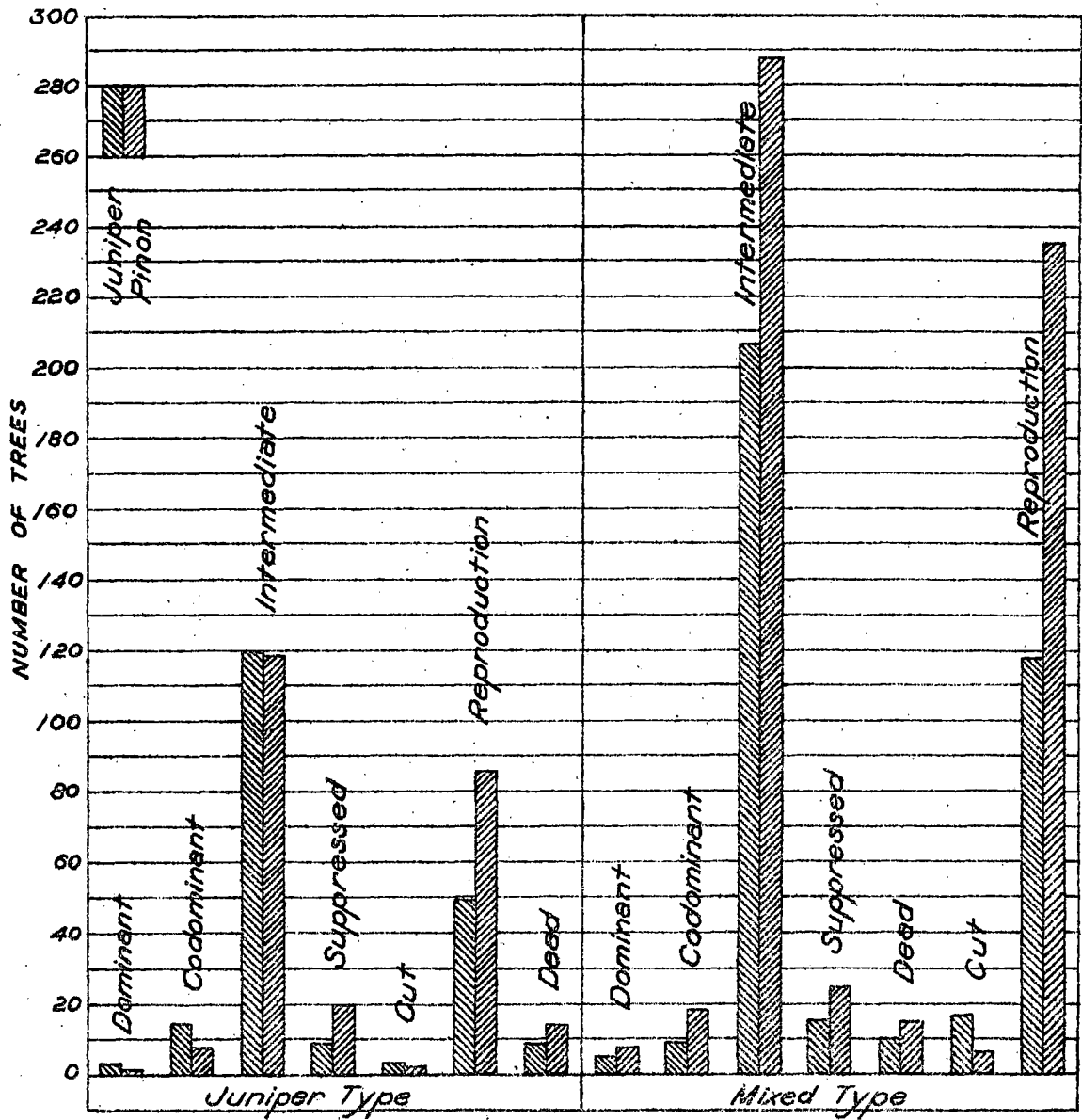


Figure 15. Composition by Number of Trees for Juniper and Mixed Types.

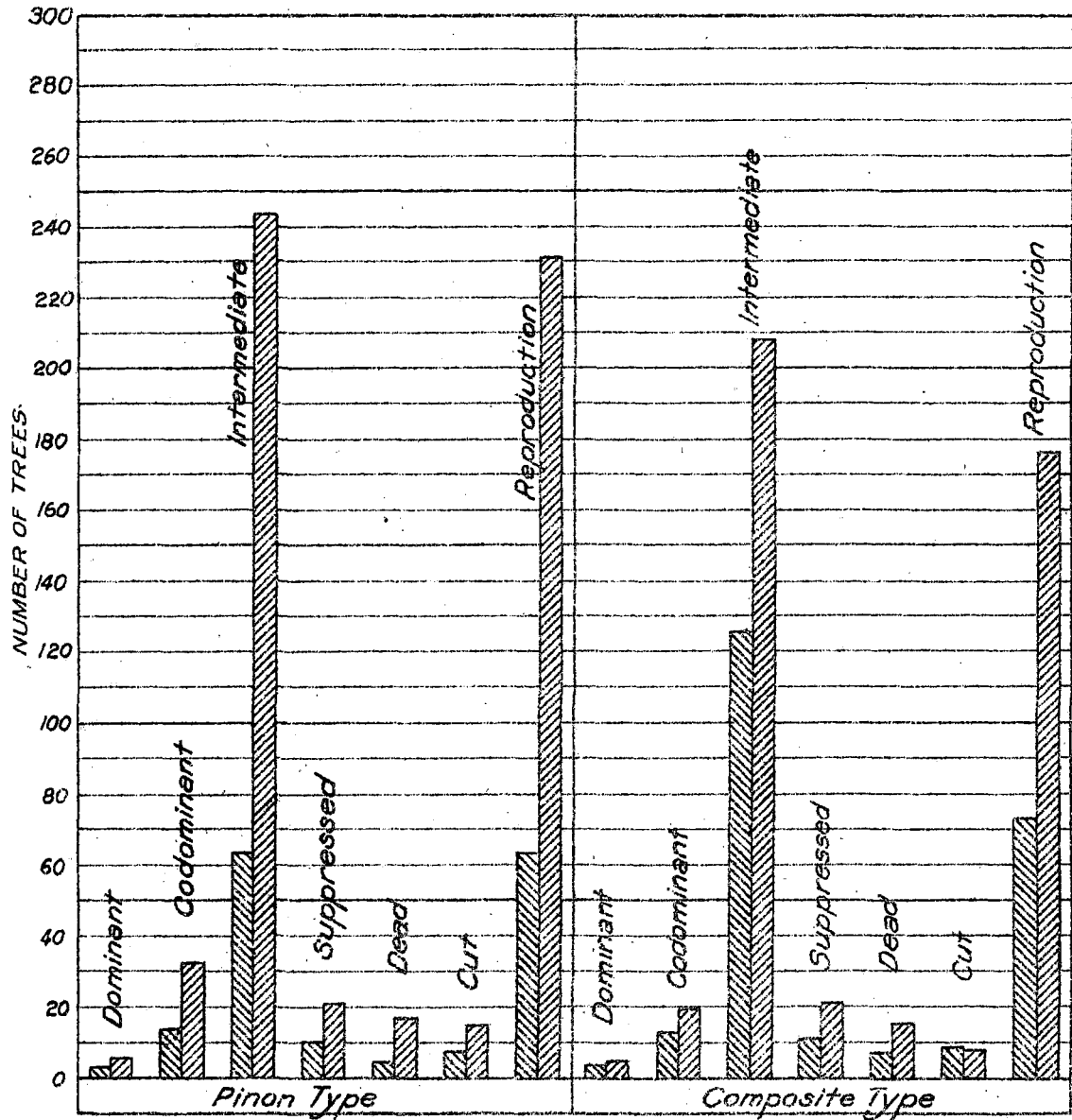


Figure 16. Composition by Number of Trees for Pinon Type and Composite of All Types.

Table 13.

Composition of Woodland Stands from Yield Tables.

Type	Basal Area-Sq. ft.				
	One-seed J.	Rocky Mt. red cedar	Sub-total Junipers	Pinon	Total
Pinon	22.8%	3.2%	26.0%	74.0%	100.0%
Mixed	40.7%	4.7%	45.4%	54.6%	100.0%
Juniper	74.6%	2.4%	77.0%	23.0%	100.0%
Type	No. of Trees				
	One-seed J.	Rocky Mt. red cedar	Sub-total Junipers	Pinon	Total
Pinon	21.9%	1.4%	23.3%	76.7%	100.0%
Mixed	39.6%	3.7%	43.4%	56.6%	100.0%
Juniper	46.8%	1.7%	48.5%	51.5%	100.0%
Type	Cubic Volume - cubic feet				
	One-seed J.	Rocky Mt. red cedar	Sub-total junipers	Pinon	Total
Pinon	26.4%	2.5%	28.9%	71.1%	100.0%
Mixed	28.5%	4.1%	32.6%	67.4%	100.0%
Juniper	80.0%	2.4%	82.4%	17.6%	100.0%
Item	Composite type				
	One-seed J.	Rocky Mt. red cedar	Sub-total junipers	Pinon	Total
Basal Area	47.6%	3.4%	51.0%	49.0%	100.0%
No. Trees	35.5%	3.4%	38.9%	61.1%	100.0%
Cu. Volume	44.7%	3.4%	48.1%	51.9%	100.0%

I. - SITE INDEX

Coniferous woodland stands of the Southwest are usually composed of two or more species of trees and are all aged, which precludes the use of conventional methods of determining site index or site quality based on age and height of dominants. Therefore, site determinations were based on basal area at one foot when the stand above 4.5 feet high averages five inches one foot above the average ground level. The small number of plots on which this study is based only permits preliminary findings.

The site classifications as shown by Figure 17, while tentative, fit the basic data for the 39 plots remarkably well. Eleven plots fall in Site Quality I, fifteen in Site II and thirteen in Site III. While distribution by diameters at one foot is poor, the groupings are satisfactory for the small number of plots.

Crown cover expressed in per cent may be used to determine site but is not as good as the basal area method previously noted. The basis is the amount of space that the crowns of trees over 4.5 feet high occupy. In dense stands, crown cover will exceed 100 per cent due to the various crown levels present. The curves presented in Figure 18 should be used with discretion. For rough work they should prove satisfactory.

Figure 19 gives yield per acre in cords, using the site classification first noted. These curves are less satisfactory than the crown density curves and are subject to the same limitations of use.

Use of this material would be as follows:

Determine crown density.

Determine site.

Determine yield in cords per acre.

Using the composite type crown density is 0.6 or 60 per cent.

The average site index is 74. The yield in cords is 11.7 cords per acre.

The site is average for the composite type.

Another expression of crown density may be used as noted by tables 14, 15 and 16, which are based on crown density expressed in per cent. Table 14 is based partly on rocky mountain red cedar, but the preponderant number of trees used in the preparation of this table were one-seed juniper.

As would be expected, more pinon trees are required per acre than juniper to have the same degree of crown density. The reverse is true for cubic or cord volumes.

Previous mention has been made that site classification by the basal area method is best. Determination of site by crown density is hardly practical but is included to show interesting relationships.

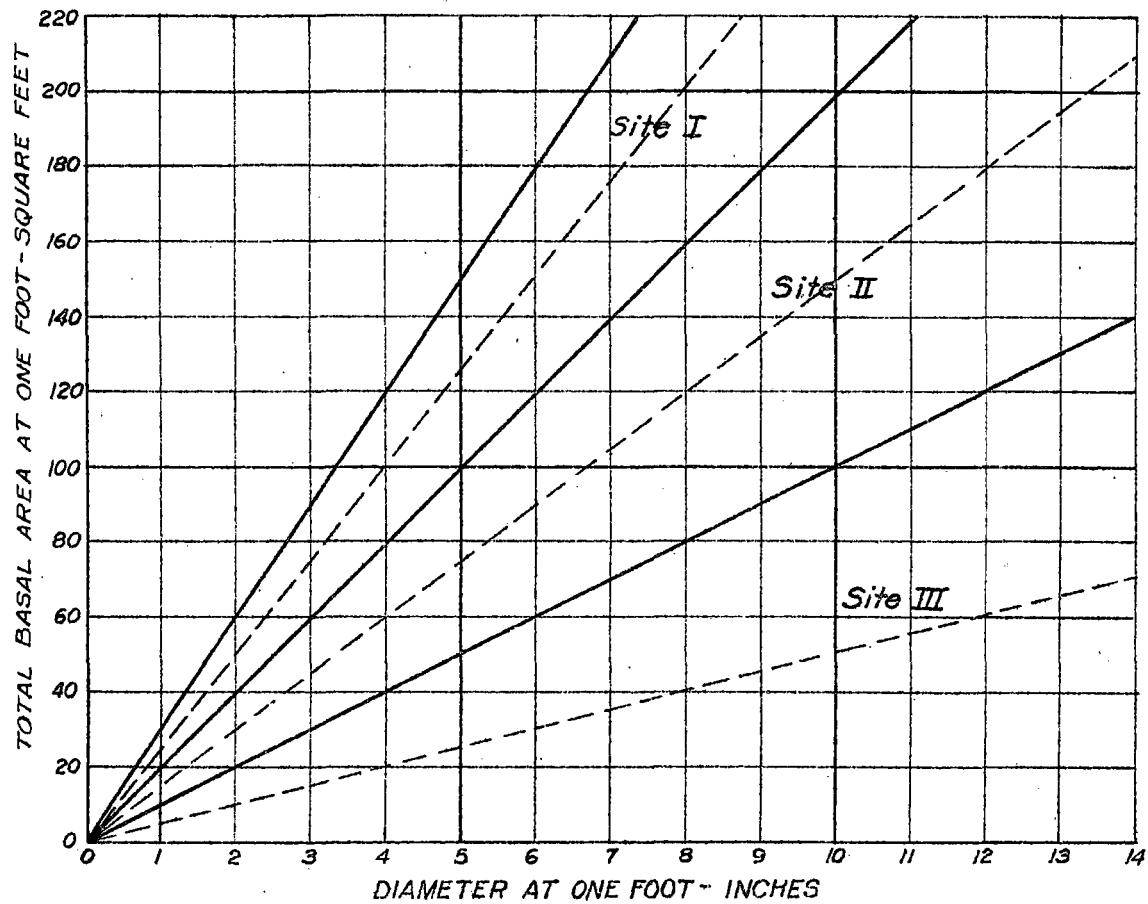


Figure 17. Basal Area Curves for Tentative Site Classifications. Basis, Basal Area Attained When the Diameter at One Foot Averages Five Inches O.B. for the Stand above 4.5 feet in Height.

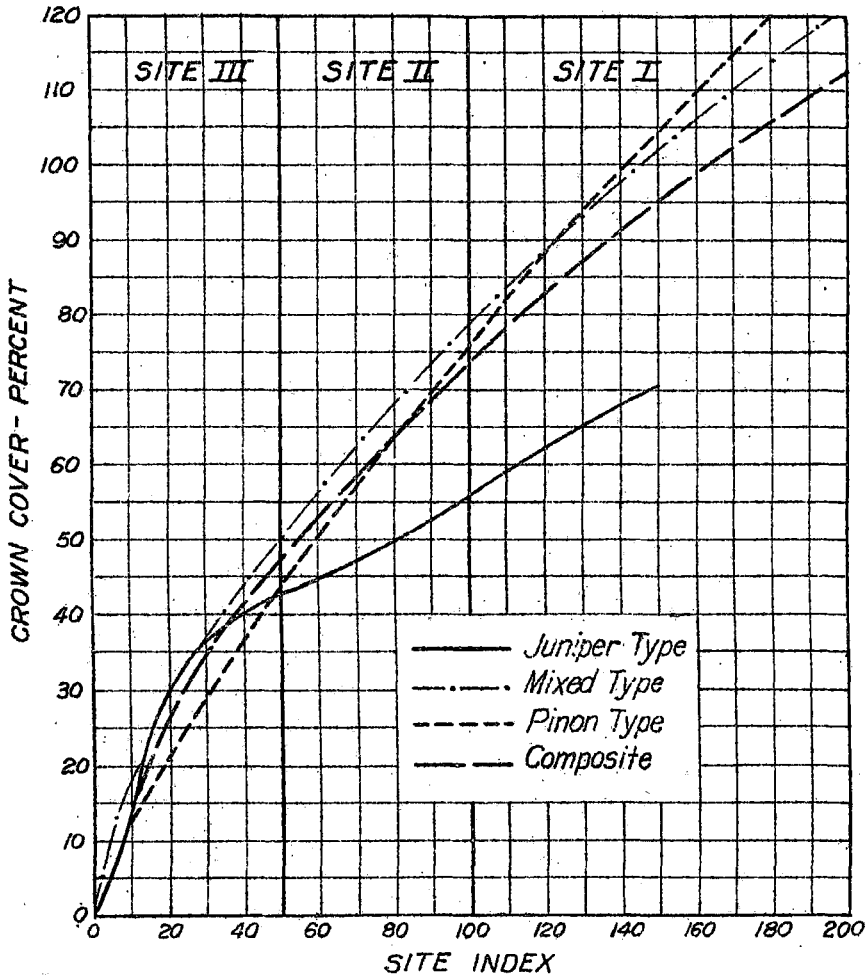


Figure 18. Crown Cover by Site Index. Basis, Basal Area at One Foot When Stand Attains an Average Diameter at One Foot of Five Inches, Outside Bark for Trees Over 4.5 Feet in Height. Curves Show Tendencies of Types.

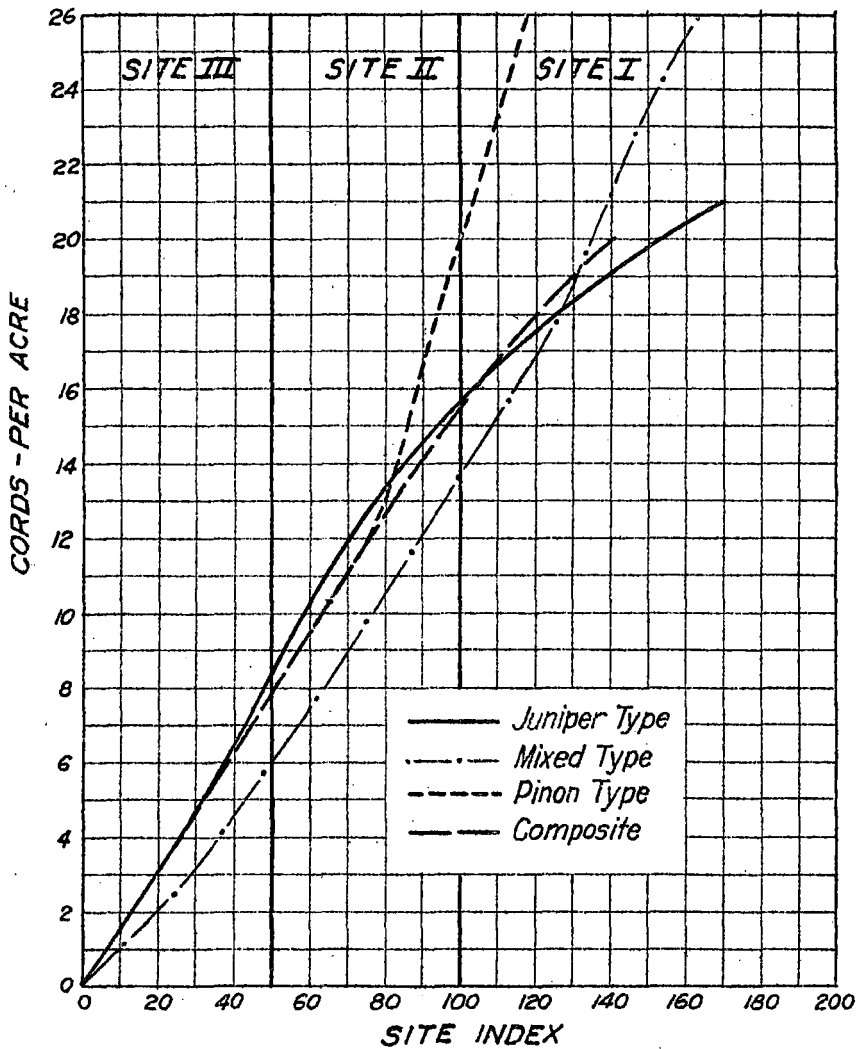


Figure 19. Cords Per Acre by Site Index. Basis, Basal Area at One Foot When Stand Attains an Average Diameter at One Foot of Five Inches, Outside Bark for Trees Over 4.5 Feet. Curves Show Tendencies of Types.

Table 14.

Number of trees and cubic volumes
per acre by crown density classes for
juniper. Based largely on one-seed juniper

Juniper			
Crown Density Per Cent	Cubic Volume per acre	Cords Per Acre	Number of trees over $4\frac{1}{2}$ Ft. in Ht. per acre
5	27.50	0.43	22
10	135.50	2.13	86
15	239.50	3.76	127
20	305.00	4.80	148
25	364.50	5.74	168
30	413.50	6.50	198
35	452.50	7.12	232
40	478.00	7.51	268
45	504.00	7.92	307
50	530.00	8.34	320
55	555.00	8.73	375
60	570.00	8.96	408
65	585.00	9.20	442
70	605.00	9.51	480
75	615.00	9.68	517
80	630.00	9.91	544
85	645.00	10.13	580
90	655.00	10.30	600
95	665.00	10.47	650
100	675.00	10.61	685

Table 15.

Number of trees and cubic volume per acre

by crown density classes for pinon.

Pinon			
Crown Density Percent	Cubic Volume per acre	Cords per acre	Number of trees over $4\frac{1}{2}$ Feet in Ht. per acre
5	42.40	0.64	68
10	68.50	1.03	130
15	88.00	1.32	190
20	129.50	1.95	220
25	178.00	2.68	243
30	278.00	4.17	268
35	600.00	9.01	294
40	652.00	9.79	320
45	720.00	10.82	360
50	780.00	11.72	405
55	830.00	12.47	475
60	880.00	13.22	540
65	925.00	13.90	610
70	965.00	14.52	680
75	1000.00	15.00	750
80	1030.00	15.47	830
85	1075.00	16.14	900
90	1090.00	16.38	955
95	1105.00	16.61	1005
100	1125.00	16.90	1060

Table 16.

Number of trees and cubic volume
per acre by crown density
classes, juniper & pinon.

Juniper and Pinon			
Crown Density Percent	Cubic Volume Per acre	Cords Per acre	Number of trees over $4\frac{1}{2}$ feet in Ht. Per acre
5	36.78	0.56	20
10	82.50	1.27	52
15	138.00	2.14	89
20	200.00	3.07	133
25	250.00	3.84	178
30	350.00	5.38	230
35	441.00	6.79	270
40	520.00	7.98	300
45	605.00	9.30	340
50	675.00	10.37	370
55	745.00	11.44	400
60	820.00	12.60	425
65	875.00	13.46	440
70	950.00	14.60	460
75	1010.00	15.50	480
80	1075.00	16.50	500
85	1130.00	17.37	520
90	1195.00	18.37	540
95	1270.00	19.52	560
100	1325.00	20.38	610
105	1390.00	21.38	680
110	1450.00	22.26	750
115	1500.00	23.07	845
120	1580.00	24.30	935
125	1615.00	24.80	1000
130	1685.00	25.92	1090
135	1740.00	26.75	1175
140	1800.00	27.63	1240
145	1840.00	28.28	1300
150	1895.00	29.14	1400

J. - YIELD

While many sites and conditions were sampled, the number of samples obtained do not allow too accurate an evaluation of yield. However, this is the best preliminary data available at present.

The yield data presented were based on trees over 4.5 feet in height and on diameter outside bark at one foot. Yield tables have been prepared by types and by species.

The curves for number of trees per acre are of the usual form for all-aged stands except there are fewer trees in the one inch class than would ordinarily be expected. Thus the curves for pinon, one-seed juniper and all species fall sharply from the numbers indicated in the two-inch diameter class. The reason for this is that many one inch trees were below 4.5 feet in height, and consequently were tallied as reproduction.

Rocky Mountain red cedar does not exhibit this tendency as it grows rapidly in the juvenile stage. Thus more stems in the one-inch class are recorded. However, in open stands, Rocky Mountain red cedar tends to assume the growth habits of one-seed juniper.

The yields in cords and solid cubic feet have been computed by types, by species for types and for a composite of all types. Gross annual yield per acre indicates the quantity of wood produced yearly which may be harvested without stand depletion.

The gross growth rate of all species and all types is approximately 1.3 per cent. For one-seed juniper it is 1.0 per cent, for Rocky Mountain red cedar 1.1 per cent and for pinon 1.5 per cent.

Table 17.

Yield Table for All Plots and All Species

Per Acre

Dia. 1 ft. inches	Age Years	No. of trees	Basal Area Sq.ft.	Cubic Volume cu.ft.	Cords	Brush Volume cu.ft.
1	25	51.9	0.221	---	---	5.7
2	44	83.3	1.606	---	---	449.0
3	61	67.9	2.580	11.42	0.174	694.7
4	78	52.5	3.456	21.35	0.326	1207.1
5	92	42.1	4.619	22.57	0.346	1346.0
6	107	34.6	5.576	32.47	0.496	1496.9
7	121	28.3	6.137	39.74	0.605	1536.6
8	136	22.5	6.249	45.55	0.688	1517.6
9	152	17.1	5.938	48.85	0.736	1456.8
10	171	12.6	5.388	50.67	0.768	1268.6
11	185	10.1	5.272	55.55	0.842	1162.1
12	200	8.0	5.003	51.51	0.780	1024.3
13	214	6.6	4.928	51.49	0.780	937.3
14	226	5.1	4.387	45.51	0.699	777.6
15	240	4.0	3.935	40.05	0.606	604.6
16	252	3.1	3.440	33.98	0.517	541.2
17	264	2.5	3.104	30.32	0.465	463.0
18	276	1.8	2.515	23.45	0.363	338.6
19	289	1.5	2.316	21.37	0.324	305.5
20	302	1.1	1.867	17.02	0.266	236.0
21	311	0.9	1.667	15.72	0.250	203.1
22	323	0.8	1.613	14.68	0.222	195.8
23	338	0.55	1.234	11.04	0.172	156.6
24	348	0.55	1.348	12.07	0.186	166.4
25	356	0.40	1.040	10.38	0.158	135.9
26	367	0.25	0.760	6.82	0.110	68.9
27	378	0.25	0.819	7.07	0.110	73.1
28	386	0.15	0.533	4.41	0.070	47.5
29	398	0.10	0.374	3.09	0.050	31.8
30	410	0.10	0.399	3.19	0.050	33.3
31	420	0.10	0.427	3.33	0.050	35.0
32	431	0.05	0.228	1.73	0.030	18.5
33	440	0.05	0.242	1.77	0.030	19.5
34	450	0.05	0.257	1.81	0.030	20.6
35	458	0.05	0.272	1.86	0.030	21.5
36	466	0.05	0.292	1.91	0.030	22.5
Totals	---	461.0	90.042	743.75	11.359	18,619.1

TABLE 18

YIELD TABLE FOR ONE-SEED JUNIPER, ALL PLOTS

PER ACRE

Dia. 1 ft. Inches	Age Years	No. of Trees	Basal Area Sq. Ft.	Cubic Volume Cu. Ft.	Cords	Brush Volume Cu. Ft.
1	28	17.2	0.084	-	-	-
2	49	25.4	0.455	-	-	114.3
3	68	23.1	0.921	7.98	0.12	240.2
4	87	18.6	1.289	8.95	0.14	483.6
5	104	14.5	1.650	10.45	0.16	529.3
6	121	11.8	1.884	11.36	0.18	540.4
7	139	9.8	2.130	12.91	0.20	529.2
8	154	8.0	2.273	13.62	0.21	512.0
9	170	6.4	2.302	13.49	0.21	464.0
10	185	5.1	2.262	13.25	0.21	420.8
11	200	4.3	2.311	19.42	0.30	391.3
12	214	3.5	2.237	18.70	0.29	350.0
13	229	3.0	2.251	18.85	0.29	330.0
14	241	2.4	2.089	17.61	0.27	288.0
15	255	2.0	1.998	16.94	0.26	204.8
16	267	1.6	1.818	15.65	0.24	224.0
17	280	1.3	1.668	14.38	0.22	195.0
18	292	1.0	1.439	12.26	0.19	162.0
19	303	0.9	1.425	12.36	0.19	157.5
20	317	0.7	1.244	10.67	0.17	130.9
21	325	0.6	1.175	10.65	0.17	118.2
22	340	0.5	1.075	9.27	0.14	105.0
23	350	0.4	0.938	8.10	0.13	89.2
24	360	0.4	1.023	8.73	0.14	94.4
25	368	0.3	0.832	8.01	0.12	75.0
26	378	0.2	0.601	5.56	0.09	53.0
27	386	0.2	0.648	5.76	0.09	56.5
28	400	0.1	0.348	2.99	0.05	30.0
29	408	0.1	0.374	3.09	0.05	31.8
30	418	0.1	0.399	3.19	0.05	33.3
31	425	0.1	0.427	3.33	0.05	35.0
32	437	0.05	0.228	1.73	0.03	18.5
33	444	0.05	0.242	1.77	0.03	19.5
34	453	0.05	0.257	1.81	0.03	20.6
35	460	0.05	0.272	1.86	0.03	21.5
36	467	0.05	0.292	1.91	0.03	22.5
Totals	-	163.85	42.861	326.61	5.08	7091.3

TABLE 19

YIELD TABLE FOR ROCKY MOUNTAIN RED CEDAR. ALL PLOTS

PER ACRE

Dia. 1 ft. Inches	Age Years	No. of Trees	Basal Area Sq. Ft.	Cubic Volume Cu. Ft.	Cords	Brush Volume Cu. Ft.
1	22	2.6	0.009	-	-	5.7
2	36	2.1	0.035	-	-	11.1
3	49	1.6	0.061	0.24	0.004	13.9
4	62	1.4	0.087	0.37	0.006	18.2
5	74	1.1	0.107	0.36	0.006	21.7
6	86	1.0	0.139	0.39	0.006	30.0
7	99	0.9	0.170	0.98	0.015	39.4
8	110	0.8	0.195	1.15	0.018	46.6
9	123	0.7	0.216	2.34	0.036	50.8
10	136	0.5	0.186	1.18	0.018	42.8
11	148	0.5	0.221	1.43	0.022	50.0
12	159	0.4	0.203	1.29	0.020	47.0
13	170	0.3	0.169	1.26	0.020	39.7
14	185	0.3	0.186	1.28	0.029	45.6
15	197	0.2	0.137	1.01	0.016	34.4
16	207	0.2	0.146	1.09	0.017	39.0
17	220	0.2	0.156	1.53	0.025	44.0
18	235	0.1	0.085	0.84	0.013	24.2
19	246	0.1	0.093	0.92	0.014	27.0
20	257	0.1	0.098	1.01	0.016	29.5
21	268	0.1	0.102	1.26	0.020	32.5
22	278	0.1	0.108	1.39	0.022	36.0
23	291	0.05	0.057	0.76	0.012	39.0
24	303	0.05	0.061	1.04	0.016	42.0
25	311	0.05	0.063	1.18	0.018	45.5
Total	-	15.45	3.090	24.35	0.389	855.5

TABLE 20
YIELD TABLE FOR PINON. ALL PLOTS.
PER ACRE

Dia. 1 ft. Inches	Age Years	No. of Trees	Basal Area Sq. Ft.	Cubic Volume Cu. Ft.	Cords	Brush Volume Cu. Ft.
1	24	32.1	0.128	-	-	-
2	42	55.8	1.116	-	-	323.6
3	58	43.2	1.598	3.20	0.05	440.6
4	73	32.5	2.080	12.03	0.18	705.3
5	86	26.5	2.862	11.76	0.18	795.0
6	100	21.8	3.553	20.72	0.31	926.5
7	112	17.6	3.837	25.85	0.39	968.0
8	127	13.7	3.781	30.78	0.46	959.0
9	143	10.0	3.420	33.02	0.49	942.0
10	160	7.0	2.940	36.24	0.54	805.0
11	176	5.3	2.740	34.70	0.52	720.8
12	191	4.1	2.563	31.52	0.47	627.3
13	203	3.3	2.508	31.38	0.47	567.6
14	216	2.4	2.112	26.62	0.40	444.0
15	229	1.8	1.800	22.10	0.33	365.4
16	240	1.3	1.476	17.24	0.26	278.2
17	251	1.0	1.280	14.36	0.22	224.0
18	261	0.7	0.991	10.35	0.16	152.4
19	272	0.5	0.798	8.09	0.12	121.0
20	283	0.3	0.525	5.34	0.08	75.6
21	293	0.2	0.390	3.81	0.06	52.4
22	303	0.2	0.430	4.02	0.06	54.8
23	312	0.1	0.239	2.18	0.03	28.4
24	321	0.1	0.264	2.30	0.03	30.0
25	330	0.05	0.145	1.19	0.02	15.4
26	339	0.05	0.159	1.26	0.02	15.9
27	348	0.05	0.171	1.31	0.02	16.6
28	357	0.05	0.185	1.42	0.02	17.5
Total	-	281.7	44.091	392.79	5.89	10672.3

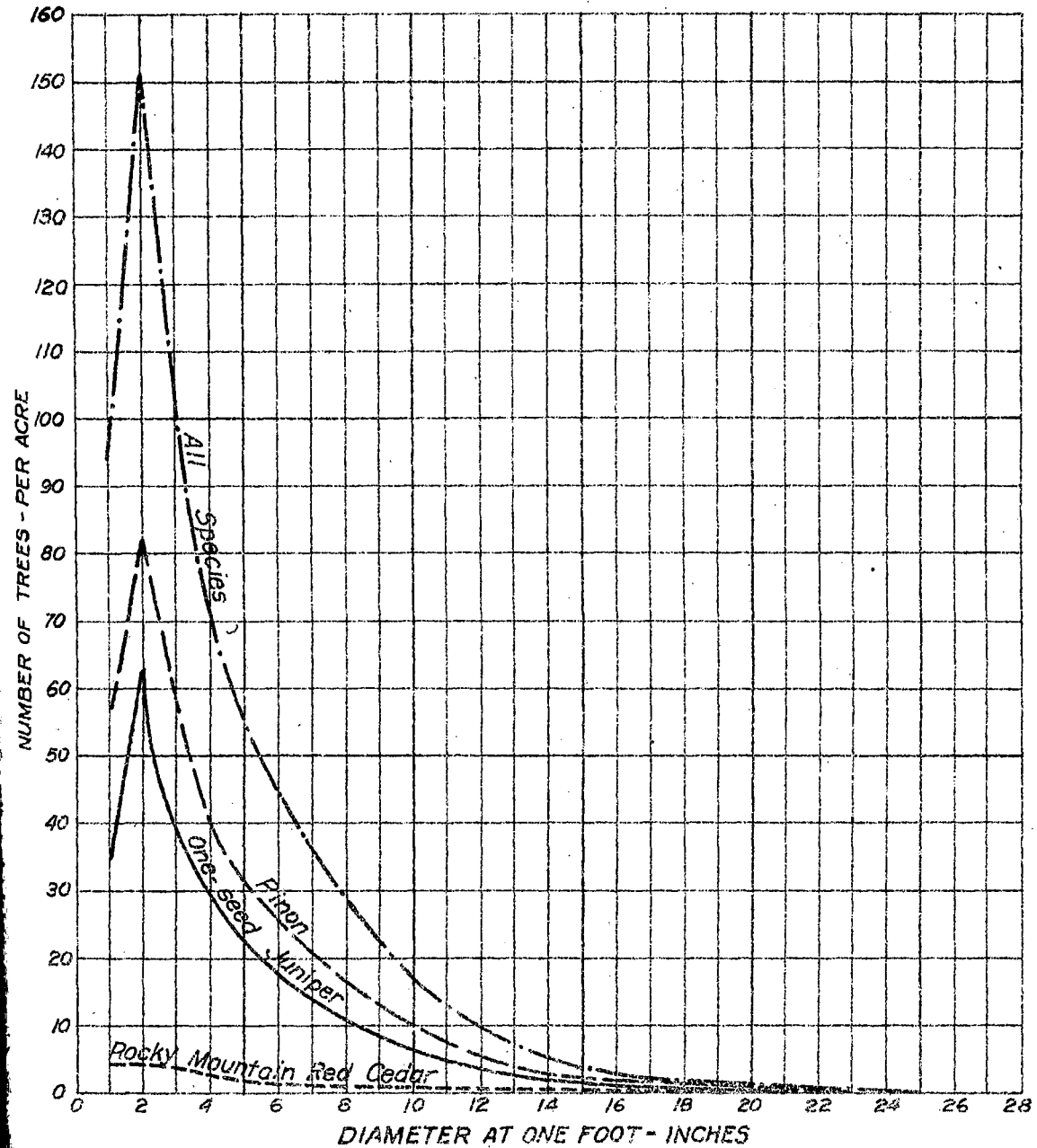


Figure 20. Number of Trees Per Acre by Diameter at One Foot, Species, and Combined Species for Composite of All Plots.

TABLE 21

YIELD TABLE FOR ALL SPECIES. PINON TYPE

PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq. Ft.	Cubic Volume Cu. Ft.	Cords
1	40.1	0.162	-	-
2	71.4	1.337	-	-
3	65.8	2.377	8.96	0.143
4	52.2	3.260	16.47	0.254
5	43.2	4.525	22.25	0.336
6	34.8	5.566	29.75	0.448
7	28.0	6.020	35.74	0.542
8	22.2	6.048	41.39	0.622
9	17.5	5.942	49.39	0.737
10	13.9	5.732	55.46	0.832
11	10.7	5.435	56.48	0.852
12	8.3	5.005	55.73	0.849
13	6.2	4.481	49.10	0.753
14	4.9	4.093	45.67	0.688
15	3.75	3.475	40.15	0.606
16	2.95	3.101	35.51	0.538
17	2.35	2.739	31.10	0.470
18	2.15	2.770	30.94	0.473
19	1.85	2.690	29.69	0.446
20	1.65	2.618	29.63	0.459
21	1.40	2.381	26.92	0.420
22	1.10	2.020	22.99	0.350
23	1.00	2.057	23.28	0.360
24	0.90	2.001	22.92	0.350
25	0.70	1.682	19.34	0.300
26	0.60	1.641	17.99	0.280
27	0.40	1.168	13.15	0.200
28	0.20	0.635	7.15	0.110
29	0.05	0.141	1.92	0.030
30	0.05	0.152	2.12	0.030
Totals	440.3	91.254	821.19	12.478

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TABLE 22

YIELD TABLE FOR ONE-SEED JUNIPER. PINON TYPE.

PER ACRE

Dia. 1 ft. Inches	No. of trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Cords
1	11.9	0.036	-	-
2	17.5	0.222	-	-
3	13.4	0.380	1.68	0.03
4	9.9	0.497	3.53	0.06
5	7.6	0.597	4.71	0.07
6	5.8	0.654	5.10	0.08
7	4.7	0.721	5.47	0.09
8	3.8	0.768	5.72	0.09
9	3.1	0.787	6.04	0.09
10	2.6	0.829	6.37	0.10
11	2.1	0.812	6.34	0.10
12	1.7	0.777	6.73	0.11
13	1.5	0.803	7.37	0.12
14	1.3	0.812	7.82	0.12
15	1.2	0.863	8.57	0.13
16	1.0	0.817	8.51	0.13
17	1.0	0.939	10.44	0.16
18	1.0	1.066	11.60	0.18
19	0.9	1.071	11.86	0.18
20	0.8	1.049	12.10	0.19
21	0.7	1.016	11.92	0.19
22	0.6	0.945	11.54	0.18
23	0.5	0.862	10.83	0.17
24	0.5	0.945	12.10	0.19
25	0.4	0.812	10.60	0.17
26	0.3	0.688	8.75	0.14
27	0.2	0.484	6.46	0.10
28	0.1	0.265	3.56	0.06
29	0.05	0.141	1.92	0.03
30	0.05	0.152	2.12	0.03
Total	96.2	20.810	209.76	3.29

TABLE 23

YIELD TABLE FOR ROCKY MOUNTAIN RED CEDAR PINON TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Cords
1	1.7	0.020	-	-
2	1.1	0.059	-	-
3	0.7	0.084	0.17	0.003
4	0.4	0.081	0.23	0.004
5	0.4	0.126	0.41	0.006
6	0.3	0.134	0.51	0.008
7	0.3	0.185	0.79	0.012
8	0.2	0.157	0.77	0.012
9	0.2	0.199	1.08	0.017
10	0.2	0.141	1.44	0.022
11	0.2	0.280	2.06	0.032
12	0.1	0.165	1.20	0.019
13	0.1	0.182	1.49	0.023
14	0.1	0.201	1.80	0.028
15	0.05	0.112	1.04	0.016
16	0.05	0.127	1.17	0.018
17	0.05	0.136	1.31	0.020
18	0.05	0.147	1.49	0.023
19	0.05	0.192	1.65	0.026
20	0.05	0.169	1.85	0.029
Total	6.30	2.897	20.46	0.318

TABLE 24

YIELD TABLE FOR PINON. PINON TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu. Ft.	Cords
1	26.5	0.106	-	-
2	52.8	1.056	-	-
3	51.7	1.913	7.11	0.11
4	41.9	2.682	12.71	0.19
5	35.2	3.802	17.13	0.26
6	28.7	4.778	24.14	0.36
7	23.0	5.114	29.40	0.44
8	18.2	5.123	34.90	0.52
9	14.2	4.956	42.27	0.63
10	11.1	4.762	47.65	0.71
11	8.4	4.343	48.08	0.72
12	6.5	4.063	47.80	0.72
13	4.6	3.496	40.24	0.61
14	3.5	3.080	36.05	0.54
15	2.5	2.500	30.54	0.46
16	1.9	2.157	25.83	0.39
17	1.3	1.664	19.35	0.29
18	1.1	1.557	17.85	0.27
19	0.9	1.427	16.18	0.24
20	0.8	1.400	15.68	0.24
21	0.7	1.365	15.00	0.23
22	0.5	1.075	11.45	0.17
23	0.5	1.195	12.45	0.19
24	0.4	1.056	10.82	0.16
25	0.3	0.870	8.74	0.13
26	0.3	0.953	9.24	0.14
27	0.2	0.684	6.69	0.10
28	0.1	0.370	3.59	0.05
Total	337.8	67.547	590.97	8.87

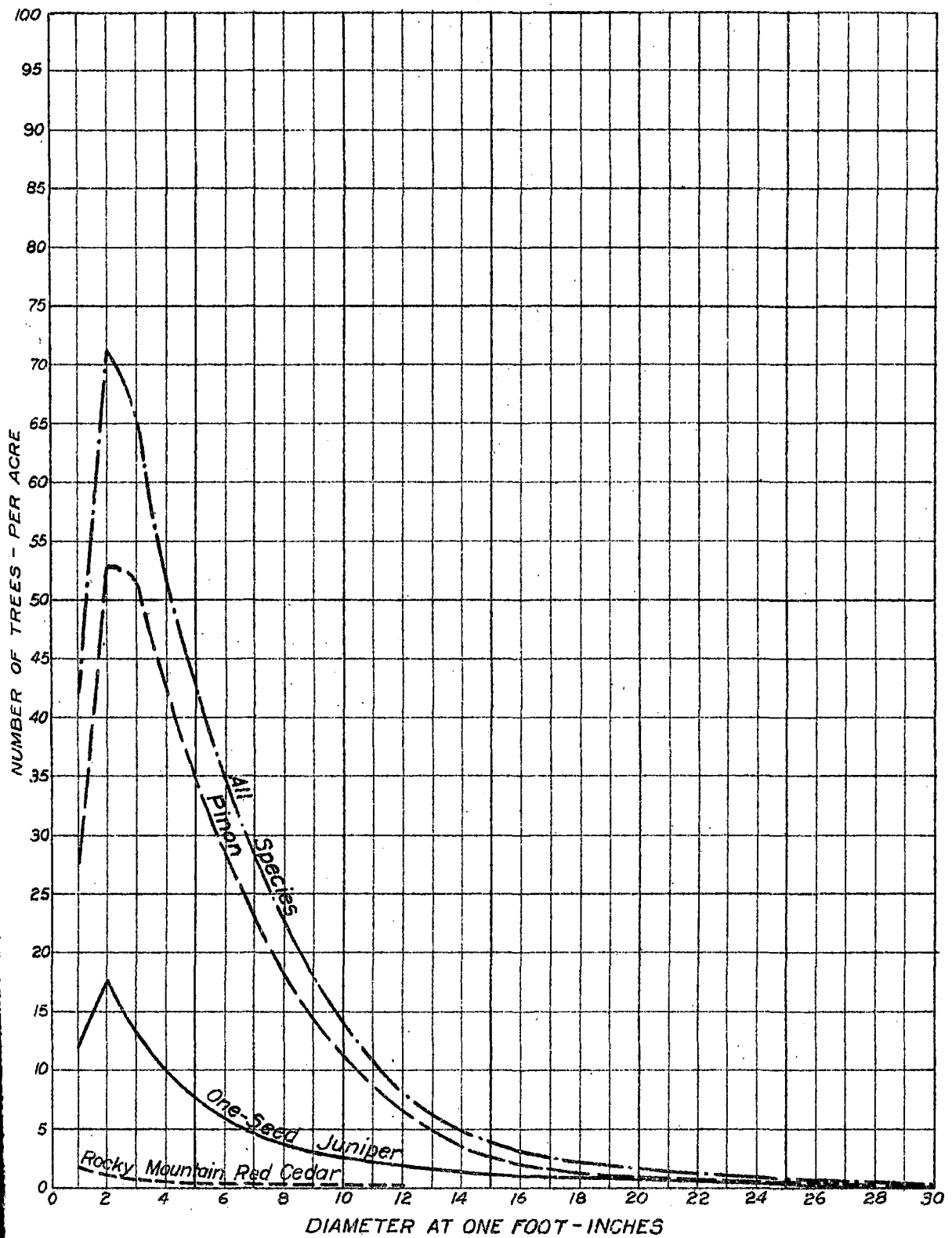


Figure 21. Number of Trees per Acre by Diameter at One Foot, Species, and Combined Species for the Pinon Type.

TABLE 25

YIELD TABLE FOR ALL SPECIES, MIXED TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Cords
1	95.1	0.404	-	-
2	150.8	2.987	-	-
3	101.0	4.023	15.72	0.244
4	71.8	4.992	26.80	0.407
5	55.2	6.255	34.33	0.529
6	44.6	7.518	44.58	0.683
7	35.8	8.123	52.13	0.797
8	28.4	8.287	59.22	0.901
9	22.0	7.998	67.61	1.035
10	16.0	7.438	71.69	1.091
11	12.7	6.970	71.56	1.086
12	9.5	6.223	67.73	1.035
13	6.8	5.289	57.67	0.878
14	5.0	4.486	49.59	0.759
15	3.8	3.850	42.77	0.656
16	2.3	2.655	28.67	0.438
17	2.0	2.533	28.22	0.422
18	1.4	2.002	21.72	0.332
19	1.1	1.709	19.45	0.298
20	0.9	1.601	17.53	0.260
21	0.6	1.244	13.51	0.210
22	0.4	0.916	9.84	0.150
23	0.1	0.254	2.17	0.030
24	0.1	0.279	2.43	0.040
25	0.05	0.150	1.34	0.020
26	0.05	0.173	1.47	0.020
27	0.05	0.175	1.62	0.030
28	0.05	0.192	1.79	0.030
Total	668.20	98.726	811.17	12.381

TABLE 26

YIELD TABLE FOR ONE-SEED JUNIPER, MIXED TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu. Ft.	Cords
1	34.1	0.150	-	-
2	64.2	1.183	-	-
3	39.5	1.628	5.02	0.08
4	30.3	2.204	10.87	0.17
5	22.0	2.507	13.72	0.22
6	17.2	2.863	15.19	0.24
7	13.6	3.074	15.91	0.25
8	10.9	3.247	16.48	0.26
9	8.3	3.105	16.26	0.26
10	6.0	2.786	14.77	0.23
11	4.6	2.620	13.95	0.22
12	3.5	2.361	13.94	0.22
13	2.5	1.972	12.35	0.19
14	1.9	1.748	11.49	0.18
15	1.5	1.590	10.76	0.17
16	1.0	1.250	8.51	0.13
17	0.8	1.108	8.02	0.12
18	0.6	0.928	6.96	0.11
19	0.5	0.776	6.58	0.10
20	0.4	0.760	6.02	0.09
21	0.3	0.631	5.13	0.08
22	0.2	0.464	3.86	0.06
23	0.1	0.254	2.17	0.03
24	0.1	0.279	2.43	0.04
25	0.05	0.150	1.34	0.02
26	0.05	0.173	1.47	0.02
27	0.05	0.175	1.62	0.03
28	0.05	0.192	1.79	0.03
Total	264.30	40.178	226.61	3.55

TABLE 27

YIELD TABLE FOR ROCKY MOUNTAIN RED CEDAR, MIXED TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu. Ft.	Cords
1	4.1	0.015	-	-
2	4.1	0.074	-	-
3	3.3	0.137	0.26	0.004
4	2.5	0.170	0.48	0.007
5	1.7	0.182	0.59	0.009
6	1.4	0.212	0.81	0.013
7	1.2	0.249	1.07	0.017
8	1.0	0.267	1.34	0.021
9	0.9	0.305	1.63	0.025
10	0.8	0.325	1.99	0.031
11	0.7	0.338	2.31	0.036
12	0.7	0.388	2.91	0.045
13	0.6	0.369	3.07	0.048
14	0.5	0.338	3.12	0.049
15	0.5	0.374	3.57	0.056
16	0.3	0.238	2.41	0.038
17	0.3	0.255	2.71	0.042
18	0.2	0.184	2.05	0.032
19	0.1	0.101	1.13	0.018
20	0.1	0.107	1.27	0.020
Total	25.0	4.628	32.72	0.511

TABLE 28

YIELD TABLE FOR PINON, MIXED TYPE

PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Cords
1	56.9	0.239	-	-
2	82.5	1.730	-	-
3	58.2	2.258	10.44	0.16
4	39.0	2.618	15.45	0.23
5	31.5	3.566	20.02	0.30
6	26.0	4.443	28.58	0.43
7	21.0	4.800	35.15	0.53
8	16.5	4.773	41.40	0.62
9	12.8	4.588	49.72	0.75
10	9.8	4.327	54.93	0.83
11	7.4	4.012	55.30	0.83
12	5.3	3.474	50.88	0.77
13	3.7	2.948	42.25	0.64
14	2.6	2.400	34.98	0.53
15	1.8	1.886	28.44	0.43
16	1.0	1.167	17.75	0.27
17	0.9	1.170	17.49	0.26
18	0.6	0.890	12.71	0.19
19	0.5	0.832	11.74	0.18
20	0.4	0.734	10.24	0.15
21	0.3	0.613	8.38	0.13
22	0.2	0.452	5.98	0.09
Total	378.9	53.920	551.84	8.32

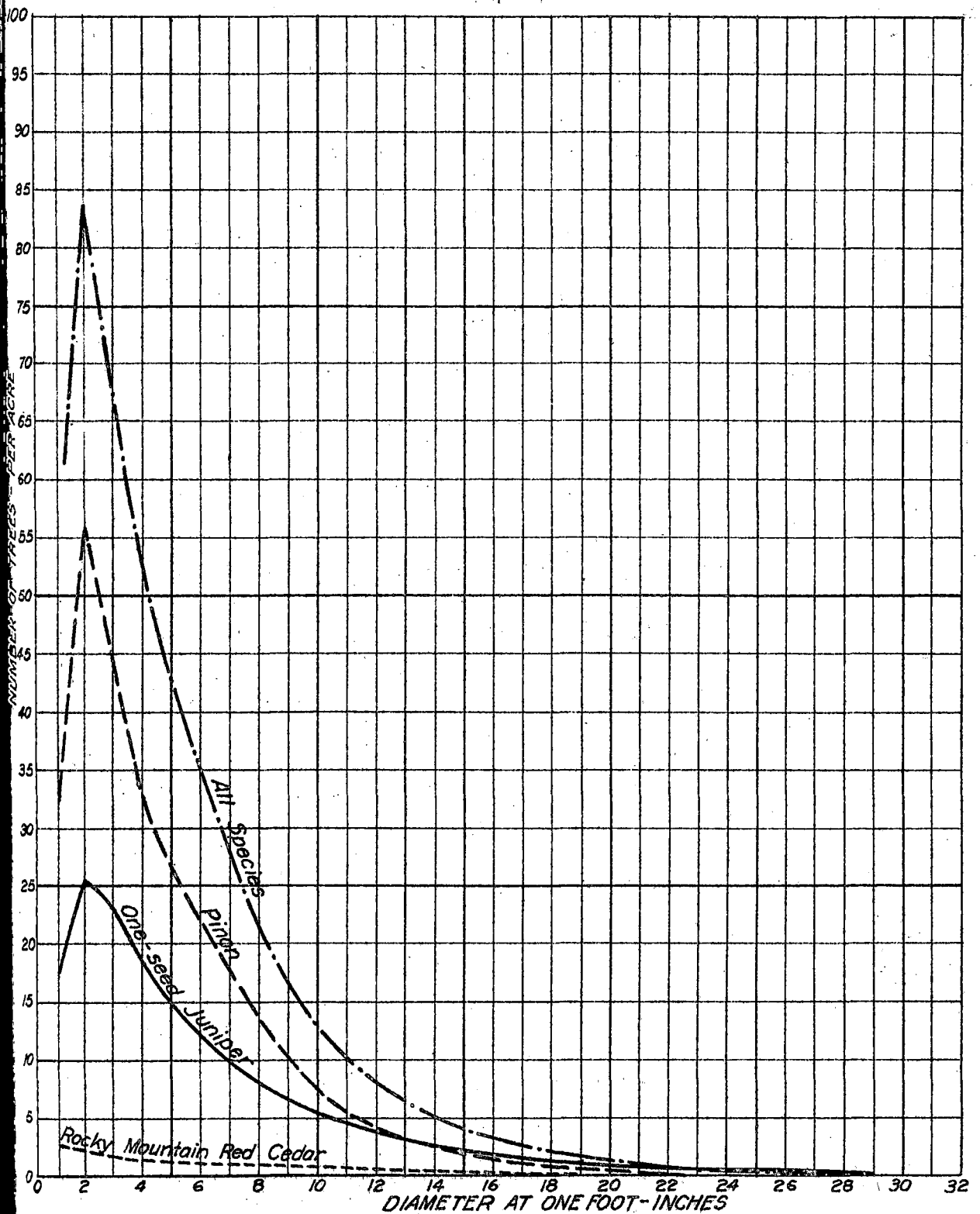


Figure 22. Number of Trees per Acre by Diameter at One Foot, Species, and Combined Species for the Mixed Type.

TABLE 29

YIELD TABLE FOR ALL SPECIES. JUNIPER TYPE

PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu. Ft.	Cords
1	36.3	0.152	-	-
2	57.9	1.151	-	-
3	46.1	1.828	5.29	0.082
4	36.2	2.530	12.38	0.195
5	27.9	3.184	14.82	0.225
6	21.3	3.627	17.69	0.270
7	15.9	3.698	18.97	0.299
8	11.7	3.481	19.54	0.309
9	9.1	3.410	20.30	0.313
10	7.6	3.510	21.94	0.341
11	6.1	3.835	28.15	0.441
12	5.6	3.851	31.02	0.474
13	4.7	3.887	31.14	0.477
14	4.1	3.831	31.96	0.501
15	3.5	3.890	31.45	0.484
16	3.0	3.707	31.13	0.487
17	2.5	3.714	29.35	0.460
18	2.0	3.262	28.83	0.455
19	1.6	2.748	24.78	0.390
20	1.4	2.645	23.77	0.370
21	1.3	2.710	24.33	0.380
22	1.2	2.759	22.63	0.350
23	1.1	3.023	22.83	0.360
24	1.0	2.797	22.38	0.350
25	0.8	2.402	21.52	0.330
26	0.7	2.387	19.57	0.300
27	0.6	2.126	17.45	0.270
28	0.5	1.935	15.04	0.230
29	0.3	1.255	9.56	0.150
30	0.2	0.894	6.61	0.100
31	0.1	0.472	3.44	0.050
32	0.1	0.508	3.58	0.060
33	0.1	0.544	3.66	0.060
34	0.1	0.579	3.76	0.060
35	0.05	0.308	1.92	0.030
36	0.05	0.329	1.98	0.030
Total	312.7	86.969	622.75	9.683

TABLE 30

YIELD TABLE FOR ONE-SEED JUNIPER, JUNIPER TYPE

PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu. Ft.	Cords
1	10.7	0.048	-	-
2	17.9	0.336	-	-
3	17.9	0.752	2.33	0.04
4	15.0	1.123	7.48	0.12
5	12.5	1.453	8.96	0.14
6	10.4	1.767	10.37	0.16
7	8.7	2.075	11.86	0.19
8	7.1	2.159	12.51	0.20
9	6.2	2.357	13.53	0.21
10	5.4	2.549	14.52	0.23
11	4.6	2.652	21.50	0.34
12	4.2	2.872	23.16	0.36
13	3.7	2.957	24.08	0.37
14	3.2	3.005	24.30	0.38
15	2.8	3.009	24.52	0.38
16	2.4	2.940	24.30	0.38
17	2.1	2.967	24.04	0.38
18	1.7	2.682	24.18	0.38
19	1.4	2.465	22.09	0.35
20	1.2	2.328	20.84	0.33
21	1.1	2.360	21.13	0.33
22	1.0	2.309	19.20	0.30
23	1.0	2.593	20.97	0.33
24	0.9	2.558	20.34	0.32
25	0.7	2.138	19.34	0.30
26	0.6	2.069	17.26	0.27
27	0.5	1.784	14.88	0.23
28	0.4	1.565	12.36	0.19
29	0.3	1.255	9.56	0.15
30	0.2	0.894	6.61	0.10
31	0.1	0.472	3.44	0.05
32	0.1	0.508	3.53	0.06
33	0.1	0.544	3.66	0.06
34	0.1	0.579	3.76	0.06
35	0.05	0.308	1.92	0.03
36	0.05	0.329	1.98	0.03
Total	146.30	64.821	494.56	7.75

TABLE 31

YIELD TABLE FOR ROCKY MOUNTAIN RED CEDAR, JUNIPER TYPE
PER ACRE

Dia. 1 ft. Inches	No. of Trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Cords
1	0.2	0.002	-	-
2	0.8	0.031	-	-
3	0.8	0.062	0.14	0.002
4	0.7	0.095	0.29	0.005
5	0.6	0.133	0.32	0.005
6	0.5	0.165	0.64	0.010
7	0.3	0.119	0.58	0.009
8	0.2	0.108	0.58	0.009
9	0.2	0.130	0.81	0.013
10	0.1	0.079	0.54	0.011
11	0.1	0.097	0.71	0.011
12	0.1	0.104	0.90	0.014
13	0.1	0.117	1.12	0.017
14	0.1	0.142	1.35	0.021
15	0.1	0.157	1.55	0.024
16	0.1	0.167	1.74	0.027
17	0.1	0.180	1.95	0.030
18	0.1	0.196	2.22	0.035
Total	5.2	2.084	15.44	0.243

TABLE 32
YIELD TABLE FOR PINON. JUNIPER TYPE
PER ACRE

Dia.1 ft. Inches	No. of Trees	Basal Area Sq.Ft.	Volume Cu.Ft.	Cords
1	25.4	0.102	-	-
2	39.2	0.784	-	-
3	27.4	1.014	2.82	0.04
4	20.5	1.312	4.61	0.07
5	14.8	1.598	5.54	0.08
6	10.4	1.695	6.68	0.10
7	6.9	1.504	6.53	0.10
8	4.4	1.214	6.45	0.10
9	2.7	0.923	5.96	0.09
10	2.1	0.882	6.88	0.10
11	1.4	1.086	5.94	0.09
12	1.3	0.876	6.96	0.10
13	0.9	0.813	5.94	0.09
14	0.8	0.684	6.31	0.10
15	0.6	0.724	5.38	0.08
16	0.5	0.600	5.09	0.08
17	0.3	0.567	3.34	0.05
18	0.2	0.384	2.43	0.04
19	0.2	0.283	2.69	0.04
20	0.2	0.317	2.93	0.04
21	0.2	0.350	3.20	0.05
22	0.2	0.390	3.43	0.05
23	0.1	0.430	1.86	0.03
24	0.1	0.239	2.04	0.03
25	0.1	0.264	2.18	0.03
26	0.1	0.318	2.31	0.03
27	0.1	0.342	2.37	0.04
28	0.1	0.370	2.68	0.04
Total	161.0	20.064	112.75	1.69

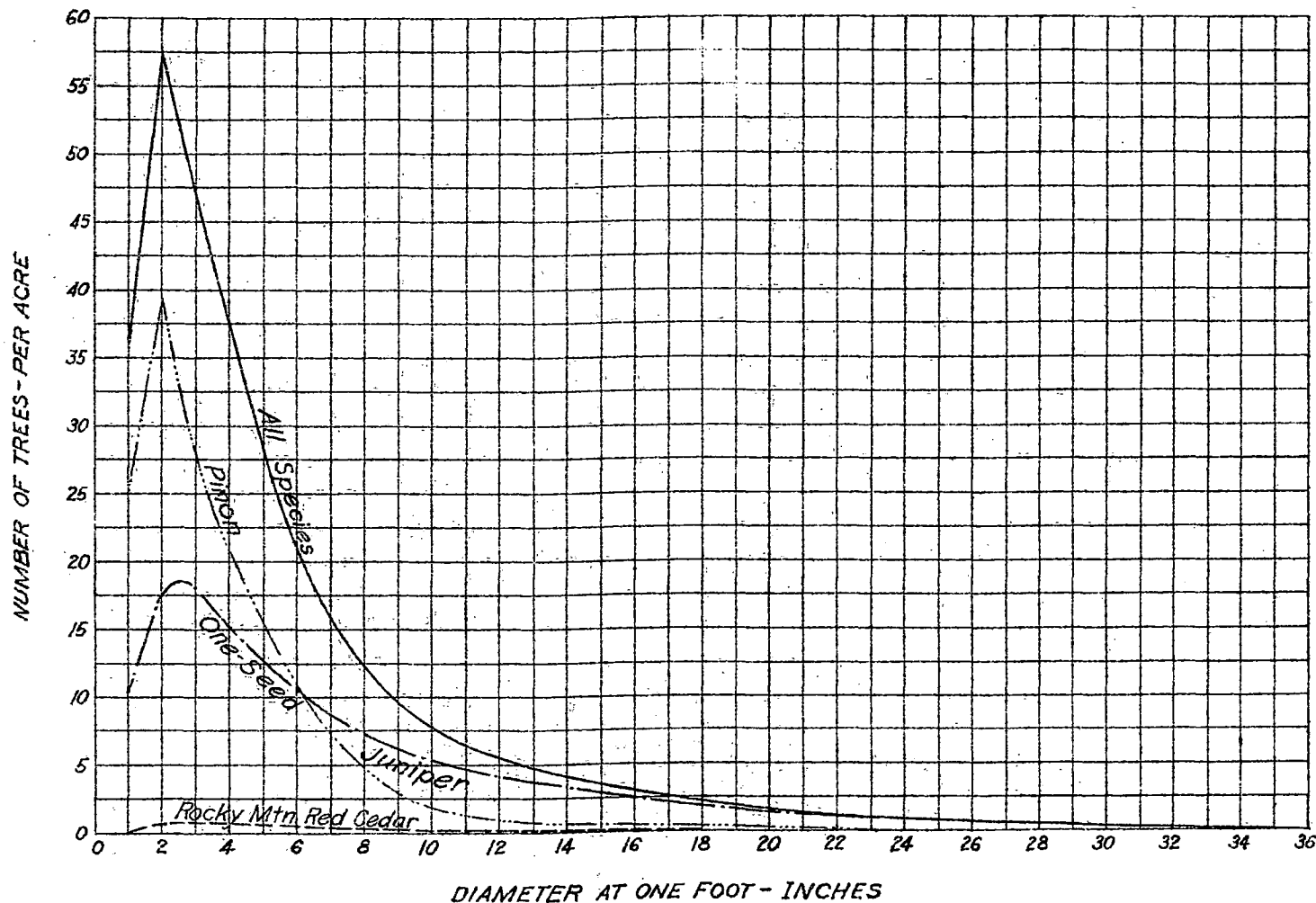


Figure a3. Number of Trees Per Acre by Diameter at one Foot, Species, and Combined Species for the Juniper Type.

TABLE 33

GROSS YIELD PER ACRE PER YEAR FOR COMPOSITE
OF ALL PLOTS BY SPECIES

Dia. 1 ft. Inches	One-Seed Juniper Cu. Ft.	Rocky Mt. Red Cedar Cu. Ft.	Pinon Cu. Ft.	Total Yield Cu. Ft.
1	-	-	-	-
2	-	-	-	-
3	0.359	0.017	0.179	0.555
4	0.295	0.020	0.505	0.820
5	0.261	0.014	0.388	0.663
6	0.194	0.012	0.559	0.765
7	0.181	0.026	0.595	0.802
8	0.163	0.024	0.585	0.772
9	0.148	0.040	0.561	0.749
10	0.133	0.017	0.507	0.657
11	0.175	0.017	0.416	0.608
12	0.168	0.013	0.347	0.528
13	0.170	0.011	0.314	0.495
14	0.141	0.010	0.240	0.391
15	0.136	0.007	0.177	0.320
16	0.110	0.007	0.138	0.255
17	0.101	0.008	0.101	0.210
18	0.086	0.004	0.072	0.162
19	0.074	0.004	0.057	0.135
20	0.053	0.004	0.037	0.094
21	0.053	0.004	0.027	0.084
22	0.037	0.004	0.028	0.069
23	0.032	0.002	0.015	0.049
24	0.035	0.002	0.016	0.053
25	0.032	0.001	0.008	0.041
26	0.022		0.009	0.031
27	0.023		0.009	0.032
28	0.012		0.010	0.022
29	0.012			0.012
30	0.013			0.013
31	0.013			0.013
32	0.007			0.007
33	0.007			0.007
34	0.007			0.007
35	0.007			0.007
36	0.008			0.008
Total	3.268	0.268	5.900	9.436
Cord	0.0513	0.0042	0.0887	0.1442

K. - MISCELLANEOUS DATA

1. Quantity of Heart wood. In Table 37 are noted the percentages of heart wood and sap wood for Rocky Mountain red cedar and one-seed juniper. Rocky Mountain red cedar is slower to form heart wood at first but produces a maximum amount of heart wood in a shorter period of time.
2. Decay. Decay impairs the strength and durability of juniper and pinon and reduces the yield of fence posts. Pinon appears to be relatively free from decay, none being found in trees with stump diameters less than 10 inches. The incidence is low, 4.0 per cent and the quantity negligible. One-seed juniper appears to be the most defective of the three species since trees above 4.0 inches at one foot are subject to decay. The incidence is 21.4 per cent and quantity 3.3 per cent of the gross volume. The incidence of decay for Rocky Mountain red cedar is almost as great as for one-seed juniper but no decay was found in trees having a stump diameter of less than 9.0 inches. See Table 38.
3. Volume-Basal Area Ratio. The one-seed juniper type produces less cord wood per square foot of basal area than either the pinon or mixed types. The pinon type produces the most wood while the mixed type is intermediate.
4. Volume - Crown Spread Ratio. In the mixed type a greater crown density is required to produce a unit of usable wood than in the other two types. The one-seed juniper type requires the least crown density to produce a unit of usable wood.
5. Posts and Poles. Posts and poles should be tallied in cruising as stands are so variable that frequency tables would usually be valueless.

TABLE 34

PERCENTAGES OF HEARTWOOD AND SAPWOOD FOR
ONE-SEED JUNIPER AND ROCKY MOUNTAIN RED CEDAR*

Dia. at 1 Ft.	Rocky Mt. Red Cedar		One-Seed Juniper	
	% Heart	% Sap	% Heart	% Sap
1	0.0	100.0	12.0	88.0
2	3.0	97.0	23.0	77.0
3	8.0	92.0	33.0	67.0
4	13.0	87.0	41.0	59.0
5	20.0	80.0	47.0	53.0
6	28.0	72.0	52.0	48.0
7	36.0	64.0	56.0	44.0
8	43.0	57.0	58.0	42.0
9	50.0	50.0	60.0	40.0
10	56.0	44.0	61.0	39.0
11	61.0	39.0	62.0	38.0
12	65.0	35.0	63.0	37.0
13	70.0	30.0	64.0	36.0
14	73.0	27.0	65.0	35.0
15	77.0	23.0	66.0	34.0
16	81.0	19.0	67.0	33.0
17	85.0	15.0	67.0	33.0
18	88.0	12.0	68.0	32.0
19	90.0	10.0	69.0	31.0
20	92.0	8.0	70.0	30.0
21	94.0	6.0	70.0	30.0
22	95.0	5.0	71.0	29.0
23	96.0	4.0	72.0	28.0
24	96.0	4.0	73.0	27.0
25			73.0	27.0
26			74.0	26.0
27			75.0	25.0
28			76.0	24.0
29			77.0	23.0
30			77.0	23.0
31			78.0	22.0
32			79.0	21.0
33			79.0	21.0
34			80.0	20.0
35			81.0	19.0
36			82.0	18.0

* Based on basal area at one foot.

Average age of sapwood: One-seed juniper, 35
yrs; Rocky Mountain Red Cedar, 34 yrs.

TABLE 35

INCIDENCE AND QUANTITY OF DECAY IN PINON,
ONE-SEED JUNIPER, AND ROCKY MOUNTAIN RED CEDAR

	Pinon	One-Seed Juniper	Rocky Mt. Red Cedar
Incidence*	3.9%	21.4%	20.0%
Quantity	1.1%	3.3%	4.5%
None below	10.0	4.0	9.0

*. Stump dia. in inches.

Only those trees that had decay in usable
material.

TABLE 36

COMPOSITE TABLE FOR BASAL AREA- VOLUME AND CROWN
SPREAD- VOLUME RATIOS

Type	Basal Area Per Cu. Ft. Sq. Ft.	Basal Area Per Cord Sq. Ft.	Crown Spread Per Cu. Ft. Sq. Ft.	Crown Spread Per Cord Sq. Ft.	Cords Per Sq. Ft. of Basal Area Cord	Cu. Ft. Per Sq. Ft. of Basal Area Cu. Ft.
Pinon	0.111	7.31	32.18	2004.5	0.137	9.00
Mixed	0.121	7.93	37.10	2433.30	0.125	8.21
Juniper	0.140	8.97	30.00	1867.50	0.111	7.16
Composite	0.122	7.95	33.26	2170.00	0.126	8.25

BIBLIOGRAPHY

Pinon

1. 1918- Chapman, H. H., and C. E. Behre.
Growth and Management of Pinon in New Mexico.
Journal of Forestry; 16:2:215-217
2. 1931- Hancock, E. A.
Giant pinons find a champion.
American Forests; 37:6:11-12.
3. 1921- Jeffers, D. S., Hoffman, A. F., and R. Philips.
The pinon-juniper land problem.
Journal of Forestry; 19:5:534-545.
4. 1930- Maule, W. M.
Lowly pinon of poor lo.
American Forests; 36:7:70-72.
5. 1922- Perry, W. L.
A word for the lowly pinon.
Journal of Forestry; 20:5:521-26.
6. 1909- Phillips, E. J.
A Study of pinon pine.
Botanical Gazette, 48:3:26-223.
7. 1935-
Pinon pine, *Pinus edulis*, Engelm.
American Forests, 41:6:46-7.

Juniper

1. 1932- Emerson, F. W.
Tension zone between the grama grass and pinon-juniper associations in northeastern New Mexico.
Ecology, 13:3:47-58.
2. 1937- Glock, W. S.
Observations on the western juniper.
Madrone, 4:1:21-28.
3. 1936- Ingram, D. C.
Note on trimming *Juniperus occidentalis*.
Proc. Soc. Am. For., 11:4:44-5.

Page 2 - Bibliography.

4. 1912- Meinecke, E. P.
Parasitism of *Phoradendron juniperinum libocedri*,
Engelm.
Proc. Soc. Am. For., 7:35-41.
5. 1933- Melchers, L. E.
Freezing injury to arbor vitae and junipers in
Kansas.
Am. Jour. of Botany, 20:593-5.
6. 1921- Miller, F. H.
Reclamation of grasslands by Utah juniper on the
Tusayan National Forest, Arizona.
Journal of Forestry, 19:647-51.
7. 1921- Pack, D. A.
After ripening and germination of *Juniperus* seeds.
Botanical Gazette, 71:31-60; and 70:139-150.
8. 1910- Phillips, F. J.
The dissemination of junipers by birds.
Forestry Quarterly, 8:60-73.
9. 1912- Phillips, F. J. and W. Mulford.
Utah juniper in central Arizona.
U.S.D.A. Circular, 197.
10. 1915- Sudworth, G. B.
The cypress and juniper trees of the Rocky
Mountain Region.
U.S.D.A. Bulletin 207.
11. 1934-
Geographical junipers.
Horticulture, 12:266-7.

- APPENDIX -

STANDARDS OF FIELD MEASUREMENT

1. Diameter. A steel diameter tape was used to measure diameters.
Recorded in inches and tenths.
2. Bark Thickness. Two measurements of bark thickness were taken with a steel tape or steel rule on freshly cut surfaces. Recorded as double bark thickness in inches and tenths.
3. Heights. A graduated rod was used for short trees and an Abney hand level for tall trees. Recorded in feet and tenths.
4. Lengths. A graduated rod or steel tape was used. Recorded in feet and tenths.
5. Crown diameter. Two diametrically opposite measurements were taken with a steel tape. Recorded in feet and tenths.
6. Crown length. A graduated rod or steel tape was used. Recorded in feet and tenths.
7. Sections. A graduated rod or steel tape was used. Recorded in feet or tenths. A permissible deviation of 0.2 foot was allowed for four foot lengths.
8. Stump height. Stump height is considered to be one foot above the average ground level.
9. Breast height. A point 4.5 feet above the average ground level.
10. Plots. Plots were laid out by means of a staff compass and steel tape. Error of closure to be not greater than 1 in 500. Plots to contain not less than 200 trees; to be 2 to 3 times longer than broad and so laid out as to cut across the topography.

11. Tree Classes - Recorded by class number.

a. Dominant.

1. Overmature, over topping, decadent, unthrifty.
2. Mature, overtopping, thrifty
3. Immature, overtopping, thrifty.

b. Co-dominant

4. Overmature, not overtopping, decadent, unthrifty.
5. Mature, not overtopping, thrifty
6. Immature, not overtopping, thrifty

c. Intermediate

7. Overmature, unthrifty, $1/2$ to $2/3$ the height of dominants
8. Mature, thrifty, $1/2$ to $2/3$ the height of dominants.
9. Immature, thrifty, $1/2$ to $2/3$ the height of dominants.

d. Suppressed

10. Decadent, unthrifty, less than $1/2$ the height of dominants
11. Mature, unthrifty, less than $1/2$ the height of dominants
12. Immature, unthrifty, less than $1/2$ the height of dominants

e. 13. Dead

f. 14. Reproduction Height Classes

1. 0 to 1 foot
2. 1 to $3\frac{1}{2}$ feet
3. $3\frac{1}{2}$ to $4\frac{1}{2}$ feet

12. Posts and Poles.

- a. Posts, round. Seven feet long, minimum top diameter of 5 inches outside bark.

b. Posts, split Twenty square inches of top surface.

5" top - one round post

7" top - two split posts

8.5" top - three split posts

10" top - four split posts

11" top - five split posts.

c. Poles

<u>Length</u>	<u>Minimum top diameter</u>
8 feet	6 inches
10 "	6 "
15 "	5 "
20 "	5 "
25 "	4 "

13. Symbols

PP - Ponderosa pine

DF - Douglas fir

PE - Pinon

JS - Rocky Mountain red cedar

JM - One-seed juniper

OM - Oaks

14. Growth studies. A well graduated scale was used. Growth rings were counted from the outside in by decades on the average radius and measurements made from the center out. Data recorded in inches and twentieths. The first measurement from the center, together with the number of rings in the fractional decade, was recorded.

15. Cord. Outside measurements of 4 x 4 x 8 feet. Measured with steel tape and recorded in cubic feet.
16. Brush. Brush was piled, the dimensions of the pile measured with a steel tape and the contents recorded in cubic feet.
17. Defect. Recorded as to type, location and size.
18. Sapwood. Average width was measured and the number of growth rings determined.

Dimensions

Crown Density

[illegible]

PSPT (BACK)

Ownership _____ Type _____

Photo No. _____ Elevation _____ Aspect _____ N E S W

Purpose _____

Location _____

Slope _____ % Rock _____ Outcrops _____ Boulders _____

Soil _____ Gravel _____ Sand _____ Loam _____ Silt _____ Clay _____ Depth 1-6" 6-12"

1-2' 2-3' 3'+plus Moisture _____ Very dry _____ Dry _____ Fresh _____ Moist _____ Wet _____

Humus _____ Trace _____ 1-2" _____ 2" plus _____ Litter-Heavy _____ Medium _____ Scant _____

Grass _____ % Weeds _____ % Density _____ Underbrush _____

Density _____ Open _____ Medium _____ Close _____

% of Area Covered _____ Species _____

SITE I II III Crown Density _____

Silvical Condition _____ Thrifty _____ Mature _____ Decadent _____

Age _____ Seed Production _____ Good _____ Medium _____ Poor _____

Reproduction

Species	0-1'	1-3 $\frac{1}{2}$ '	3 $\frac{1}{2}$ '-4 $\frac{1}{2}$ '	Tot.

Ave. Dia.

Ht. Dom.

No. Dead

No. Injured

No. Trees

No. of Clumps

Cu. Vol.

Cord Vol.

Age to 1 Ft.

Total B. A.

Age Dom.

Stocking

No. Diseased

REMARKS:

LIBRARY
ROCKY MOUNTAIN FOREST & RANGE
EXPERIMENT STATION
240 WEST PROSPECT STREET
FORT COLLINS, COLORADO 80521